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THE COMPOUND AND MIXED NESTS OF AMERICAN ANTS.

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PART II. THE KNOWN CASES OF SOCIAL SYMBIOSIS AMONG AMERICAN ANTS.

SOCIAL symbiosis among ants occurs in what are called "compound" and "mixed" nests. These terms are used in the sense of Forel's "fourmilières doubles" and "fourmilières mixtes." The former are defined ('74, p. 52) as "nests inhabited simultaneously by two or more ant colonies belonging to two or several hostile species." The latter term was adopted by Forel from Pierre Huber ('10). It includes the nests which are amicably inhabited in common by ant colonies belonging to different species. Both categories were later accepted by Wasmann ('91) with slight changes, and, somewhat more accurately, designated as "zusammengesetzte Nester und gemischte Kolonien" (compound nests and mixed colonies). Wasmann included all the various forms of compound and mixed nests known in 1891 in the following table ('91, pp. 176–178):

"*A.* Compound Nests (*zusammengesetzte Nester*). The consociating ants maintain independent households, or *ménages; i.e.*, constitute separate colonies. This form of symbiosis occurs between ants belonging either to the same or to different subfamilies.

I. Accidental (*i.e.*, Occasional) Forms:

1. Nests established in close proximity to each other by ants which have certain predatory proclivities. Examples: *Tetramorium cæspitum* with *Formica sanguinea; Dorymyrmex pyramicus* with *Pogonomyrmex barbatus.*
2. Nests established in close proximity to each other, with the subsidiary object of securing comfortable, warm, and secure quarters. Examples: *Formica fusca* and *Myrmica ruginodis* with *F. rufa* and *pratensis; Leptothorax muscorum* under the bark of pine trunks surrounded by *rufa* nests; *Myrmecina latreillei* Latr. with *F. rufa* and *exsecta.*

II. Regular Forms:

1. Thief ants: *Solenopsis fugax* and *Solenopsis orbula* with ants of much greater size.
2. Guest ants: *Formicoxenus nitidulus* with *Formica rufa* and *pratensis; Xenomyrmex stollii* with *Camponotus abscisus.*

B. Mixed Colonies (*gemischte Kolonien*). The different consociating ants carry on a single household, thus constituting a single colony. This form of symbiosis occurs only between ants belonging to the same subfamily.

I. Normal (*i.e.*, Regular) Forms:

1. The dominant species has its own workers, with toothed mandibles. Colonies clearly of predatory origin. *Formica sanguinea* ♂ ♀ ☿ and their developmental forms ⩭[1] workers and worker pupæ of *F. fusca* or *rufibarbis* or both, or of *F. schaufussi* or *fusca* (in North America).
2. The dominant species has its own peculiar workers without toothed mandibles.
   a. The dominant species is represented by ♂ ♀ ☿ and their developmental stages, the auxiliaries only by the workers and their pupæ. Predatory colonies:
      α. Colonies clearly predatory in origin: *Polyergus rufescens* ⩭ *F. fusca* or *rufibarbis* (or very rarely both), *Polyergus lucidus* ⩭ *F. schaufussi.*
      β. Colonies probably of predatory origin: *Strongylognathus huberi* ⩭ *Tetramorium cæspitum.*

[1] The sign ⩭ is used to express the union of two species to form a single colony. The name of the auxiliary (slave) species is always placed after the sign.

b. The dominant species is represented by ♂ ♀ ☿ and their developmental stages, the auxiliaries by the workers and their developmental stages and by fertilized females. Colonies arising by affiliation (*Bundescolonien*): *Strongylognathus testaceus* ⩭ *Tetramorium cæspitum.*

c. The dominant species appears to be represented only by the ☿ and its developmental stages, the auxiliaries by ♂ ♀ ☿ and their developmental forms.[1] Probably predatory colonies, which, however, do not arise like the above through the robbing of the pupæ of strange nests, but by the dominant species driving out the latter and taking possession both of their nest and brood. *Tomognathus sublævis* ⩭ *Leptothorax acervorum* or *muscorum.*

3. The dominant species has no worker form: *Anergates atratulus* ♂ ♀ and their developmental stages ⩭ *Tetramorium cæspitum* (workers only). Perhaps these colonies might be more conveniently designated as guest colonies.

II. Accidental (Abnormal) Forms:

1. Artificial mixed colonies arising through affiliation. Examples: *Formica sanguinea* ⩭ *pratensis*; *F. rufa* ⩭ *pratensis*; *Polyergus rufescens* ⩭ *rufa.*

2. Artificial mixed colonies of predatory origin:

a. Produced in confinement: *F. sanguinea* ⩭ workers of *fusca* or *rufibarbis* (normal auxiliaries); *rufa, pratensis, cinerea, exsecta, pressilabris* (abnormal auxiliaries).

b. Occurring in a state of nature: *F. sanguinea* ⩭ workers of *fusca* and *pratensis* or *rufibarbis* and *pratensis.*

3. Natural, abnormal, mixed colonies:

a. Unusual auxiliaries, with the usual dominant species. Predatory colonies:

Form. sanguinea ⩭ workers of *pratensis.*
" " " " " *rufa.*
" " " " " *rufa* and *fusca.*

b. Usual auxiliaries, with an unusual dominant species. Colonies probably arising by affiliation: *F. pratensis* ⩭ *fusca, truncicola* ⩭ *fusca, exsecta* ⩭ *fusca.*

c. Neither species living, as a rule, with other ants, either as auxiliaries or as dominant species: *Tapinoma erraticum* ⩭ *Bothriomyrmex meridionalis.*

[1] This assertion now requires modification, since Adlerz has published his later observations ('96).

C. Various combinations of the regular and irregular types of compound nests and mixed colonies. Examples: *Solenopsis fugax* with *Formica sanguinea* = *fusca*; *Tomognathus* = *Leptothorax* with *F. rufa*."

While this table leaves little to be desired in point of logical construction, it is scarcely an adequate expression of the facts at the present time. Nor could this be expected, as a decade has elapsed since its publication. It seems worth while to replace it by a number of coördinated categories, for two reasons. First, the case of *Leptothorax emersoni*, described in the first part of this paper, is in certain respects clearly transitional between Forel's and Wasmann's leading categories of compound and mixed nests, so that the dignity of these main groups is thereby considerably impaired. Second, the various cases of compound and mixed nests obviously represent several independent and more or less divergent lines of phylogenetic development, as Wasmann has shown ('91, p. 239). Hence it seems advisable to attempt a natural grouping of the cases, even at the expense of multiplying categories. I have, therefore, adopted the following headings, which may be cited with their equivalents in Wasmann's table:

I. *Plesiobiosis.* Double nests (in Forel's sense); Wasmann's accidental forms of compound nests. (*A* I, 1 and 2.)

II. *Parabiosis.* (Forel '99) Not included in Wasmann's table.

III. *Cleptobiosis.* Wasmann's "Diebsameisen"; first regular form of compound nest. (*A* II, 1.)

IV. *Xenobiosis.* Inquilines, or guest ants; Wasmann's "Gastameisen"; second regular form of compound nest. (*A* II, 2.)

V. *Dulosis.* Slavery. ("Esclavagisme," Forel.) Wasmann's normal forms of mixed colonies. (*B* I, 1 and 2.)

VI. *Colacobiosis.* Social parasitism (Forel); Wasmann's third case of normal mixed colonies. (*B* I, 3.)

VII. *Synclerobiosis.* Mixed nests of uncertain origin and meaning. Wasmann's last case (*B* II, 3 *c*) of accidental (abnormal) mixed colonies.

Although of considerable interest, the artificial mixed colonies (Wasmann's *B* II, 1 and 2) are omitted in this scheme, because they are mere beginnings in a field of experiment that has been little cultivated in Europe and is still untouched in America. It might be possible to include them with the cases of synclerobiosis. The natural abnormally mixed nests (Wasmann's *B* II, 3 *a*) are best treated in connection with the normal cases of dulosis. Combinations of regular and irregular mixed and double nests (Wasmann's category *C*) are rather rare and exceptional, and may be placed as compounds of the simpler relations under some one of the seven headings above enumerated.

I. Plesiobiosis.

As restricted in the present paper, plesiobiotic, or double nests comprise only those cases in which two, or rarely more, colonies of ants of different species excavate their galleries in close contact with one another. They are usually established under stones or logs, but a peculiar group of such nests is formed by several species that live within the precincts of the huge, exposed, mound-like nests of the agricultural ants (species of Pogonomyrmex). The colonies inhabiting double nests are usually inimical, or at best indifferent to one another. Hence, when living under stones or in old logs, they very carefully wall up the intervening space, so that the galleries belonging to the two households cannot inosculate.

Two classes of double nests may be distinguished. One of these embraces a vast series of merely accidental associations of two (or, more rarely, more) species. The associations of the other class are claimed to occur with a certain regularity and frequency, as if one or both of the species concerned were settling into definite and constant symbiotic relations. The cases of the former class are of comparatively little interest, except in so far as they represent what must have been the very first step in the development of the more specialized unions (xenobiosis, dulosis, colacobiosis, etc.). Any attempt at cataloguing these various associations would be unprofitable, if not impossible. As an illustration of such cases, it may suffice to

mention, in passing, one very beautiful example. On March 9 of the current year I found two double nests under large stones on opposite sides of a road near Austin, Texas. The ants were in both cases the huge black Ponerine *Pachycondyla harpax* and the fine honey-yellow *Camponotus fumidus*, var. *festinatus* (=*Formica festinata* Buckl.). In each case the latter species had excavated its nicely finished galleries and chambers under the middle of the stone, while the former had extended its few broad and irregular burrows along the surface so as nearly to encircle the Camponotus nest. The contrast between the color of these large ants, the one belonging to the most primitive, the other to the most specialized subfamily of the Formicidæ, was scarcely greater than that exhibited by their architecture. As soon as the nests were uncovered the Camponoti sniffed the presence of their black neighbors and hastily retreated into their galleries; while the Ponerinæ seemed as oblivious of their fellow-tenants as the occupants of a Chicago apartment building. Similar nests of *P. harpax* and *C. maculatus*, subsp. *sansabeanus*, are not infrequent in the neighborhood of Austin, but these, too, are merely accidental associations, as all three of the species mentioned are nearly always found occupying single nests.

The second class of plesiobiotic colonies, *viz.*, those which have been considered by some authors as incipiently symbiotic, really represent very little advance on cases like those above described. I am convinced that the supposed regularity of these associations may be largely the result of hasty or inadequate observation. In several instances the two species of ants are quite as often, or even more frequently, found in single nests. Usually one of the species is of diminutive size, and this has led observers to suppose that they were dealing with a small and feeble ant living under the wing of a formidable neighbor. It is, however, quite as probable that the two species occur together, because both affect the same natural conditions, such as soil, moisture, presence or absence of vegetation, etc. This is noticeably the case with Pogonomyrmex and its various satellites.

1. **Myrmecina graminicola** Förster.

Myrmecina graminicola (*M. latreillei* Curt.) is a small, rather rare ant, occurring both in Europe and North America. On our continent it is represented by two subspecies — *americanus* Emery, with its variety *brevispinosus* Emery, and a second undescribed subspecies recently discovered in Texas.

The habits of the European Myrmecina have been observed by Forel ('**74**, pp. 352–353). He found it living in small colonies under stones. It is rather sluggish and cowardly. When disturbed, instead of defending itself or running away like most other ants, it relies on the protection afforded by its very hard integument, rolls itself up in a ball and "feigns death." Forel found that it would not attack *Tetramorium cæspitum* or *Strongylognathus huberi*, even when these ants invaded its nest. The European Myrmecina is described as having a *penchant* for forming double nests with other ants. One of the two colonies found by Forel was near a nest of *Formica rufa*, the other near a nest of *Ponera coarctata*. Wasmann ('**91**, p. 176, footnote) also found a Myrmecina colony in a nest of *Formica exsecta*.

So far as I have been able to observe, our American subspecies appear to have the same habits as the European form. A few specimens of the new subspecies found at Austin were under a stone which covered besides a small colony of *Formica subsericeo-neorufibarbis* Emery (= *F. gnava* Buckl.). Two nests of the subspecies *americanus*, variety *brevispinosus*, found at Colebrook, Conn., during the past summer, were associated with *Stenamma fulvum*, subsp. *aquia* Buckl., and *Ponera coarctata*, subsp. *pennsylvanica* Buckl.

2. **Leptothorax muscorum** Nylander.

According to Emery ('**95**, p. 318), *Leptothorax muscorum*, like Myrmecina, occurs in the United States as well as in Europe, but nothing is known concerning its habits in the former locality. In Sweden, according to Adlerz ('**86**, p. 210), it has a decided proclivity for living within the confines of *Formica rufa* nests. Both Adlerz and Wasmann ('**91**, p. 225) lay stress

on this peculiarity as representing a decided step towards the conditions exhibited by the guest ant, *Formicoxenus nitidulus* (*q.v.*). It is of even greater interest in connection with the habits of its congener, *L. emersoni*.

3. **Monomorium minutum** Mayr., var. **minimum** Buckley.

This widely distributed ant forms small but very populous nests, containing from one to a dozen or more deälated queens and hundreds or even thousands of workers. It is very common under stones in the open cedar brakes in many places about Austin, Texas. Usually its nests are solitary, but it frequently forms double nests with the larger ants of the vicinity. I have often found it with *Camponotus maculatus*, subsp. *sansabeanus*; *C. fumidus*, var. *festinatus*; *Formica subsericeo-neorufibarbis*; *Pachycondyla harpax;* and under small stones on the summits of the nest-cones of *Pogonomyrmex barbatus*, var. *molifaciens* Buckl. The large ants are assailed with fury when the nests are disturbed and they accidentally stumble into the galleries of the Monomorium. These minute black ants, however, are not altogether averse to the society of other ants, as is shown by their forming mixed nests with two interesting species to be considered below, *viz.*, *Leptothorax* (*Dichothorax*) *pergandei* Emery and *Epœcus pergandei* Emery.

4. **Forelius fœtidus** Buckley (= **Forelius mccooki** Forel).

Attention was first directed to this small, dull yellowish dolichoderine ant by McCook, who found it living amicably within the nest boundaries of the Texan agricultural ant (*Pogonomyrmex barbatus*, var. *molifaciens*). The substance of his observations is contained in the following remarks ('79, p. 202): "Numbers of these ants were frequently seen traveling in long lines across or near to the nest of Barbatus (Pl. XXIV, Fig. 118). Usually their route was established upon blades of grass growing on those nests which were covered with the Aristida, or along the low tufts of grass on the margin of the disk. They seemed to prefer this elevated transit to moving directly upon the surface, which they touched only

when a break in the herbage compelled them to descend. They traveled in single, or 'Indian' file, one behind another. . . . The specimens which I preserved were taken from a small colony found within the bounds of a large Barbatus formicary which was being excavated. The agriculturals took no notice of their tiny neighbors, at least never interfered with them, and the two species seemed to be upon the most friendly terms with each other."

McCook's observations are, in the main, correct, so far as they go, but they are so incomplete as to give a wrong conception of the habits of Forelius. This ant is extremely common at Austin, where McCook made the above-quoted observations. It really prefers dry soil, nearly or quite destitute of vegetation. It throws up its little crater-shaped mounds of earth in great numbers along the paths and roads, and on warm sunny days travels in straggling files over all the barren lands. Sometimes, however, it nests under stones on the dry hillslopes, and it is in such situations that one often finds the largest and most flourishing colonies, containing many deälated queens and thousands of workers, larvæ and pupæ. The fact that it often builds within the confines of the Pogonomyrmex formicaries is easily explained, for, though the agricultural ant naturally prefers grassy regions, nevertheless, through its singular habit of clearing away the vegetation over a large circular area, it establishes the very conditions that are preferred by the Forelius. The "friendly relations" with Pogonomyrmex are perhaps to be explained by the very small size and active movements of Forelius, which thus escapes the attention of its huge neighbors. In this respect the dolichoderines seem to be in the same position as the small white podurans (Cyphodeira), which run about unheeded in the galleries and chambers of the Pogonomyrmex nests.

5. **Dorymyrmex pyramicus** Roger.

In connection with some rather fanciful passages from the manuscript of Lincecum, McCook ('79, p. 197 *et seq.*) records several observations of his own on the relations of *Dorymyrmex*

pyramicus to *Pogonomyrmex barbatus*. Though the former ant, which ranges from Colorado and North Carolina to the Argentine Republic, is not uncommon at Austin, I have not often observed it in this locality. But I have found its small earthen mounds in very great numbers about Aguas Calientes in Mexico. Here it occurs quite as frequently outside as within the formicary boundaries, both of the typical *P. barbatus* and its variety, *molifaciens*. Like Forelius, Dorymyrmex is an ant of the barren soil, and its occurrence within the formicary precincts of the agriculturals is probably open to the same explanation. It is, however, far more pugnacious than Forelius, and, though tolerated by Pogonomyrmex, it resents any intrusion on the part of its larger neighbors. Both Forelius and Dorymyrmex, like many other dolichoderines, emit a rank secretion, which is in all probability protective.

6. **Dorymyrmex pyramicus** Roger, var. **flavus** McCook.

According to McCook ('82, pp. 155–158), this variety occurs with *Pogonomyrmex occidentalis* Cresson in Colorado. "There was scarcely a formicary which came under observation, from first to last, that had not upon the clearing one or more colonies of the erratic ant, *Dorymyrmex insanus* Buckley, or a new species of variety, *D. flavus* McCook. Usually there are two or three nests, sometimes four, located upon different parts of the pavement. These are small moundlets of fine soil, surrounding a central opening which leads into an irregular series of galleries and chambers. The same insects are parasitic upon the disks of the agricultural ants of Texas, and exhibit there characteristics similar to those in the Garden of the Gods. They are small, very active, irritable, intensely pugnacious, and courageous to the last degree. The manner in which these little fellows bullied and badgered their occident hosts was amusing, and indeed amazing." Nests of *Dorymyrmex pyramicus*, var. *flavus*, are rather common at Austin, but as yet I have failed to find them within the Pogonomyrmex formicaries, although I have no doubt that they occasionally occur in such situations.

7. **Pheidole carbonaria** Pergande, **subsp. calens** Forel.

At Aguas Calientes, Mexico, I observed several nests of this small, timid Pheidole on the slopes or about the bases of the beautiful gravel cones of the typical *Pogonomyrmex barbatus*, and its variety, *molifaciens*. The Pheidole was not found elsewhere in the vicinity, but my stay was too brief to enable me to assert that this ant really exhibits a more definite association with Pogonomyrmex than that of Forelius and Dorymyrmex. From the appearance of its soldiers, *Pheidole carbonaria* would seem to be a seed-storing species like our Texan *Pheidole kingi* André, var. *instabilis* Emery, and the Northern *Pheidole pilifera* Roger (= *pennsylvanica* Roger). If this is true, the Mexican insect may be a thief-ant feeding on the seed stored by the agriculturals in their large chambers, which are often sufficiently near the surface of the mounds to be invaded by small ants.

8. **Formica sanguinea** Latr.

McCook ('82, p. 152) found colonies of *Formica sanguinea*, with their slaves, within the clearings of three different nests of *Pogonomyrmex occidentalis* in Colorado. These and several other ants appeared to be tolerated in this situation by the occident ants. Such observations show that the association of ants with the Pogonomyrmex cannot be in all cases prompted by a desire for greater protection, since *F. sanguinea* is a bold, predaceous species, quite capable of making its way independently. It also shows that the formicary precincts of the agricultural ants may be open to some intruders of considerable size. Experience has taught me that it is not an easy matter to determine the attitude of these ants towards other animals. This is evident from the following jottings from my notebook: *Pogonomyrmex barbatus* sometimes permits the leaf-cutting ants (*Atta fervens*) to wear a groove-like path diagonally across its disk. It will also allow large tenebrionid beetles (*Eleodes tricostatus*), often to the number of six or eight, to stalk about for hours unmolested on its nest, and to feed on the refuse vegetable matter accumulated within the confines of

the pavement or even on the gravel cone.[1] On the other hand, I have counted on a single pavement no less than ten of the balls of dung abandoned by the Canthons (*C. lævis*) which had been driven away from their precious charges by the ants. Malodorous beetles like *Chauliognathus scutellaris* when placed on the nests are seized by the ants, at once carried to the edge of the pavement, and dumped over the boundary. Man and the larger domestic animals are soon attacked when they stand within the disk, and the horned toad, which seems to feed very largely on these ants, is treated in the same manner. (See Edwards, '96.)

II. PARABIOSIS.

Forel ('99) introduced the term "parabiosis" to designate a peculiar form of compound nest with inosculating galleries, in which different species of ants have their households strangely intermingled but not actually blended. Only one typical case of this description is known, but some remarkable nests in tillandsias recently observed by me in Mexico are in certain respects similar to the case described by Forel, so that they may be included, at least provisionally, in the same category.

9. Dolichoderus and Cremastogaster.

The interesting observations made by Forel ('99, pp. 380, 381) in the United States of Colombia during the spring of 1896 are here translated in full:

"I frequently observed, originally in the neighborhood of Santa Martha, two species of ants belonging to different genera and even subfamilies, a Dolichoderus and a Cremastogaster, both shining black, the former very large, noticeably larger than the latter, usually running in the very same files, both over the ground and on the trees and undergrowth, in the most perfect amity. The files were very long and dense, so that the ants met and elbowed one another continually. The two species went foraging on the trees, the Cremastogaster searching mainly for plant lice and Coccidæ, the Dolichoderus

[1] Several years ago I observed another species of Eleodes similarly engaged on the nests of *P. occidentalis* in Wyoming.

for the sap of the plants. For this reason the files bifurcated towards their ends, each species going to its own destination. I finally discovered in the trunk of a mango a large termite nest which had been appropriated by the two species of ant under discussion, and served them as a common dwelling in a manner hitherto unknown. The time was decidedly propitious, as each species had its winged sexes and its pupæ in the nest. The nest was inhabited as it had been left by the termites without additions or alterations. In no portion of the nest was there a blending of the two species of ants. Some of its corners were still tenanted by the termites. But the chambers and galleries throughout nearly their whole extent were occupied either by the Cremastogaster with their females, males, and pupæ, or by the Dolichoderus with the corresponding sexes and developmental stages. Each species had its own household, in contradistinction to the mixed formicaries of our Polyergus and Formica, which have but a single household in common. But all the chambers and galleries inhabited by one of the two species communicated freely with the cells tenanted by the other, and, as if intentionally, the apartments of one were interlaced with those of the other. Instead of one species taking possession of one-half of the nest, and the other of the remainder, they interdigitated throughout, so that there was not a piece of the nest as large as an egg which did not contain both species. The whole nest was about four or five decimeters in diameter. Thus the case is altogether different from that of the double or compound nests in Europe, where two or several inimical species may have their galleries interlacing to some extent but not inosculating. In this case we are concerned with an amicable association for lodging and for the files, which go foraging together, but without actually blending, so that the two species lead an independent life side by side. Hence the term 'parabiosis' which I have thought best to apply to this kind of association. It should be remarked, however, that the parabiotic association of these two species is not constant, though very frequent. I have also found the nest of each species by itself."[1]

[1] In conclusion Forel calls attention to the fact that some birds exhibit a similar parabiosis, *e.g.*, the joint flocks of *Corvus cornix* and *C. corone* in Europe.

10. *Nests in Tillandsias.*

On December 27 of the past year, while collecting ants in a small grove at the head of one of the *barrancas* near Cuernavaca, Mexico, I happened on some peculiar nests, concerning which I can find no account in the literature. After collecting a number of species under the stones, I turned my attention to the limbs and foliage of the acacia and guava trees overhead. On accidentally pulling to pieces one of the large bud-like epiphytic tillandsias (probably *Tillandsia benthamiana* Klotzsch), very common both in this and other localities about Cuernavaca, I was surprised to find it containing whole nests of ants, with their larvæ and pupæ snugly packed away like so many anchovies in the spaces between the moist overlapping leaves. A closer inspection showed that the ants had gnawed little holes through the leaves to serve as entrances to their chambers. These holes occasionally perforated a single leaf, but quite as often they threaded several leaves and extended to the very core of the bud. Sometimes a single colony of ants was divided up into companies, each occupying the space under a single leaf. But the most remarkable fact concerning these nests was the frequent occurrence of two or even three flourishing colonies belonging to different species in a single tillandsia, the whole habitable basal portion of which was rarely more than 2–3 inches long by 1½ inches in diameter. Often these colonies were curiously intermingled in such a manner that though there was no actual blending and the space under a single leaf was always occupied by ants of the same species, still, whole colonies or portions of a single colony were often completely surrounded by leaf spaces occupied by another colony. During the few hours which I could devote to collecting, the following seven species — three of them new to science, as Professor Forel informs me — were taken from the tillandsias:

1. *Cremastogaster brevispinosa* Mayr., var. *minutior* Forel.

2. *Camponotus abdominalis* Sm., subsp. or var. between *esuriens* Sm. and *mediopallidus* Forel.

3. *Camponotus rectangularis* Em., var. *rubroniger* Forel.

4. *Cryptocerus aztecus* Forel.
5. *Cryptocerus wheeleri* Forel.
6. *Leptothorax petiolatus* Forel.
7. *Pseudomyrma gracilis* Fabr., var. *mexicana* Em.

Of these species, which are here enumerated in the order of decreasing frequency, — the first being far and away the most abundant, — I noticed the following combinations occurring in single buds: Nos. 1 + 2; Nos. 1 + 2 + 4; Nos. 1 + 3 + 4; Nos. 1 + 5 + 6; Nos. 1 + 7.

While I am not certain that the nests of the different species could communicate with one another, I am confident, nevertheless, that these ants must be very tolerant of one another, for their entrances were situated on such a small surface as to be of necessity very close together. This is the more astonishing on account of the great diversity of behavior exhibited by the different species. When I was tearing the leaves asunder the little Cremastogasters attacked me vigorously, but their lilliputian stings and mandibles could scarcely perforate my epidermis. The huge *Camponotus abdominalis*, however, rushed out in a body, and the powerful mandibles of the soldiers, reinforced by the copious formic acid batteries of the whole company, often compelled me to drop the tillandsia and forego further exploration of its leaves. The two species belonging to the grotesque genus Cryptocerus were as gentle as lambs, preferring to rest quietly on my hands and clothing. The timid little Leptothorax took to their legs, while the superb wasp-like Pseudomyrmas made dashes at me from among their glistening larvæ and pupæ, but returned with precipitation as if afraid to abandon their offspring.

As the tillandsias appeared to suffer no injury from their tenants, and were even preparing to send forth their long spikes of reddish flowers, I was at first inclined to see in this association of plants and ants another case of symbiosis (*sensu stricto*). But apart from v. Ihering's contention ('94 p. 365 *et seq.*) that the number of "Ameisenpflanzen" in tropical America has already been considerably exaggerated, the above view also loses in probability from the fact that at least four of the seven

species which I have enumerated occur also under other conditions in the neighborhood of Cuernavaca. Nos. 1, 2, 3, and 7 were found nesting in the dead trunks and branches. No. 2 also nests under stones, and it is probable that 4, 5, and 6, at least occasionally, nest in dead wood, like many other species of the same genera in other regions. The little Cremastogaster uses a black, paper-like substance for constructing perforated partitions within the spaces which it inhabits and for closing up the openings left at the tops of the chambers by the slightly divaricating leaves of the tillandsia. A colony of this species was also found inhabiting the cup-like cavity of one of the peculiar flower-like excrescences on the branches of the guava trees — the "flores de guavera" of the inhabitants of Cuernavaca. The ants had closed the wide orifice of the cup with a layer of the black papery substance and had left a small opening near its center to serve as an entrance. The relations of the ants to the tillandsia would seem, therefore, to be very similar to those often formed by several other species with empty galls and hollow thorns, both in Mexico and other countries. These relations are of great interest as one of many expressions of the remarkable plasticity of instinct in these insects.

Living colonies of *Cremastogaster brevispinosa* and *Cryptocerus aztecus* were brought back to Austin and confined together in a Fielde nest.[1] Although the two colonies took up their habitation in different parts of the same chamber, they were never seen to quarrel with each other. On one occasion some of the Cremastogasters even ventured to lick the red, saucer-shaped heads of the Cryptocerus soldiers!

III. CLEPTOBIOSIS.

Those ants which live in or near the nests of other species and prey on the larvæ or pupæ, or surreptitiously consume

[1] This artificial nest invented by Miss Adele M. Fielde ('00) is superior to any other that I have used. It requires closer attention than the Janet nest in order that the requisite amount of moisture may be maintained, but this slight disadvantage is outweighed by numerous advantages. The ventilation of the chambers is excellent, the closest inspection of the ants is possible, and the nests are easily handled, transported, and cleaned.

certain substances in the nests of their hosts, may be grouped together as clebtobiotic species. Owing to the present incompleteness of our knowledge, this category is not very clearly circumscribed, so that further researches may greatly extend its meaning or lead to its division into several categories.

All the known cleptobiotic ants are of minute size and of subterranean habits. They are pale colored and seem to have a predilection for living with rather large ants. The minute species of Solenopsis (*S. fugax* Latr., *orbula* Emery, *latro* Forel, *molesta* Say), and according to Forel ('94, pp. 23, 24) certain species of Monomorium (*M. andrei* Saunders), and the species of the oriental genera Oligomyrmex, Melissotarsus, Carebara, Tranopelta, and Aëromyrma, belong to this category. *Monomorium termitobium* Forel enters into cleptobiotic relations with termites in Madagascar. Forel notes the following significant facts concerning these different species: "It is more than probable that the extremely minute size and subterranean life of the worker of these species are the results of natural selection. The workers are very small, yellow, and blind, or nearly so, whereas the large females and males, of a brown or black color, with wings and large eyes, are witnesses to the fact that the minute size, etc., of the worker is due to an extraordinary regressive development. The female of *Carebara lignita* West. is 20 mm. long and 4–6 mm. in diameter, while its worker, which I owe to the kindness of M. Emery, is only 2 mm. long! It is obvious that the minute size of the worker is its safeguard. For owing to its minuteness it succeeds in insinuating itself into the young brood of large ants or termites without being seen by the defenders. It assassinates the young in their swaddling-clothes, incapable of defending themselves. As it lives very near its hosts, it requires neither size nor strength for seeking its food at a distance, and it is therefore in a position to nourish its enormous females and males with facility. Thus it is easy to see how this form of parasitism should lead to a diminution in the size of the worker, in depriving it of its eyes, and in giving it a pale color, while the females and males which mate in the air retain their size, visual organs, and coloration."

The only cleptobiotic ant which has been at all carefully studied is the European *Solenopsis fugax*, a species with minute yellow workers and black males and queens. We owe

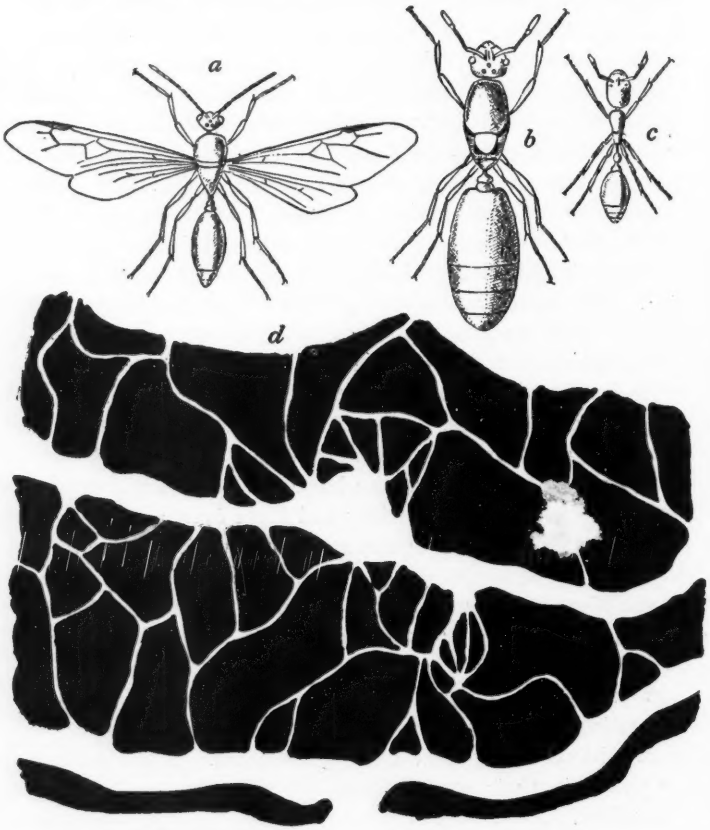


FIG. 10.—*Solenopsis fugax* Lat. (after Wasmann). *a*, male; *b*, deälated female; *c*, worker; *d*, portion of nest, showing tenuous galleries of Solenopsis entering the large galleries of the host-ant.

our knowledge of the behavior of this species to the labors of Forel ('69, '74), Wasmann ('91), and Janet ('97). I insert Wasmann's figure (slightly modified) of this insect and its nest, together with a translation of Janet's *résumé* ('97, pp. 58–60),

as both are of considerable interest in connection with our closely allied American species, *Solenopsis molesta:*

"The Solenopsis may establish itself near almost any other ants of our country. It is found especially with *Formica fusca, F. rufibarbis, Polyergus rufescens, F. rufa, F. pratensis, F. sanguinea, F. cinerea, Tetramorium cæspitum,* and *Myrmica scabrinodis.* Frequently it is possible to observe that the two nests are in close contact with each other. The Solenopsis nest may partially surround that of its neighbors, or it may even be excavated in part in the masses of the earth separating the galleries of the latter. That the two nests so near each other are not merely two contiguous nests, but deserve a special name such as the term 'double nest' employed by Forel, is proved by the fact that fine connecting galleries enable the Solenopsis to make incursions into the nests of their neighbors, where, as we shall see, they find an abundance of food. Wasmann ('91, p. 21) mentions an extremely populous nest provided with some twenty queens and extending in a semicircle around the subterranean portion of a *Formica pratensis* nest, with which it communicated by means of fine pillaging galleries. Forel and Wasmann, however, have also met with isolated nests.[1] At Beauvais I was able to ascertain, by following carefully during several hours the spading of a piece of land which was exposed to the south and had been left untouched for several years and was almost devoid of stones, that the nests of Solenopsis may often be isolated, or at least noticeably distant from the nests of any other species. Nevertheless, this distance does not at all exclude the possibility of a communication by means of long galleries with the ant nests of the neighborhood, *e.g.*, with those of the Tetramorium, which were not rare in the same piece of ground. It is probable that the Solenopsis, when necessary, manages to go a considerable distance in search of the ant pupæ that appear to constitute its principal food, but there is, nevertheless, a propensity to settle near the nests which furnish this food, and this approach is favored by the presence of stones, under which ants have such a pronounced tendency to shelter themselves. . . . In the sandy

[1] Emery ('95) also records the occurrence of such nests near Bologna, Italy.

soil of the piece of land above mentioned I obtained some fine and very clear vertical sections of the nests of the Solenopsis. They consisted of small chambers of a circular form measuring 8–20 mm. in diameter and only 6–8 mm. in height. Most of these chambers were at least several centimeters apart. Their floors were remarkably clean, smooth, and even hardened. They were connected by tenuous galleries, often less than 2 mm. in diameter, entering the chambers at their ceiling, at their lateral walls, or at their floors, and uniting with their surfaces by means of a perceptible infundibular orifice. Forel ('74, p. 385) saw several Solenopsis leave the earth and steal in among a stack of cocoons which had been heaped up by some *Formica pratensis* that had been dumped on the ground. The Solenopsis set to work perforating the cocoons and cutting the pupæ to pieces, thus destroying a great number of them. Forel is correct in his inference that the Solenopsis behave in the same manner in double nests. At this writing I repeat this observation daily on an artificial double nest of *S. fugax* and *F. rufibarbis*. Every day I give the Solenopsis about ten cocoons of Lasius queens, placing them near the entrance of the nest. It is not long before the Solenopsis make their appearance. From ten to thirty of them climb up onto each cocoon and cover it with little perforations, which, finally becoming confluent, enable them to reach its contents. If it contains a pupa, the legs and antennæ fall an easy prey to the mandibles of the Solenopsis. In this case the victim is cut into, sucked, and torn into very small pieces, which the ants hasten to carry away into the interior of the nest. The operation is much more difficult if the contents is a larva which has just spun its cocoon, or a pseudonymph. I have seen the Solenopsis drag a larva of this kind into the interior of the nest and keep working at it for twenty-four hours. At the expiration of this period the larva began to look flaccid and was covered with little black dots, which were sometimes double, corresponding with the little wounds made by the mandibles. Numbers of the Solenopsis were busy lapping up the liquid which exuded from the wounds, but it was not until thirty-six hours had elapsed that the larva was entirely devoured. Large

species of ants are unable to enter the nests of their neighbors, as the galleries of the latter are too narrow; and when the two species happen to meet one is inclined to believe, with Forel ('74, p. 246), that the small size of the Solenopsis renders them invisible to the larger ants. Then, too, in case of a conflict, the Solenopsis are numerous enough and sufficiently well armed with stings to kill even *Formica sanguinea*. In my double artificial nests I often saw one of the latter killed by a group of five or six Solenopsis, but on such occasions I also found a considerable number of Solenopsis cadavers on the refuse-heaps."

11. **Solenopsis molesta** Say.

The European *S. fugax* is represented in North America by a very closely allied species, — *S. molesta* Say. (= *S. debilis* Mayr.), — a minute yellow ant with yellow queens and dark brown males. The species has a very wide geographical range. It has long been known from the Eastern and Northern States and appears to be equally common in Texas. Although not mentioned in Forel's monograph ('99), it extends through Mexico, where I have taken it as far south as Cuernavaca in Morelos. Emery has described a variety *validiuscula* from California.

The habits of *S. molesta*, so far as I have been able to observe them, are the same as those of *S. fugax*. Although like its European congener it sometimes occurs in isolated nests, and even in houses, it has, nevertheless, a decided predilection for forming compound nests, essentially like those of *S. fugax*, with larger ants. In the Northern States it often consorts with the different species of Formica, Lasius, Stenamma, and Myrmica. In Texas it is of almost regular occurrence in the large nests of *Pachycondyla harpax* and *Odontomachus clarus*, and often occurs with the different earth-inhabiting species of Camponotus (*C. fumidus*, var. *festinatus* Buckley; *C. maculatus*, subsp. *sansabeanus*). In Mexico I have taken it with a variety of *Odontomachus clarus*. In one nest of *S. molesta*, discovered near Austin, I found the workers feeding on a dead cricket lying in the galleries of *Pachycondyla harpax*. As

S. molesta sometimes occurs far from the nests of other species, it would seem that it must often feed on other substances than the larvæ and pupæ of ants. Under these circumstances its diet may be similar to that of the European species which Emery ('95, p. 277, footnote) found near Bologna feeding on the bones and dead bodies of small animals.

12. **Pheidole lamia** n.sp. (Fig. 11 *a–c*).

This aberrant Pheidole, which I have recently taken near Austin, Texas, is, I believe, to be included among the cleptobiotic ants. It is, unfortunately, of very rare occurrence, so that up to the present time I have found only two of the nests — both under stones in rather moist, shady places. One of these nests contained a small number of workers which were feeding on a partially decomposed caterpillar. The other, containing a greater number of workers (about twenty-five), was on a refuse heap consisting of several dead ants, in the midst of a nest of *Camponotus maculatus*, subsp. *sansabeanus*. The honey-yellow workers were only 1.5 mm. long, and to the unaided eye so closely resembled the very common workers of *Solenopsis molesta* as to convince me that I must

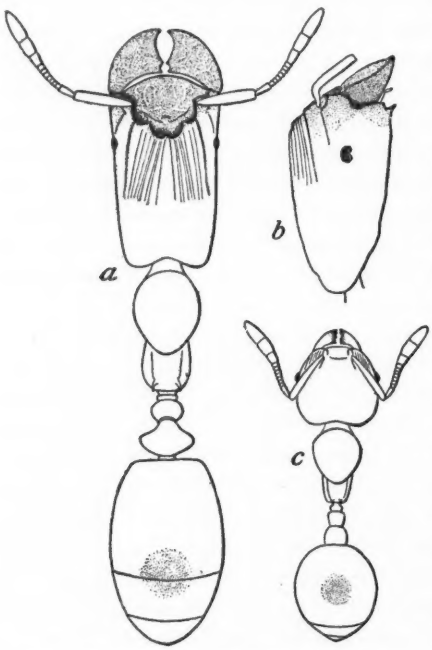


FIG. 11. — *Pheidole lamia* n.sp. *a*, soldier; *b*, head of same in profile; *c*, worker.

have overlooked these ants on several former occasions. They had evidently been feeding on the dead Camponotus and were moving in and out of their tenuous galleries excavated below the refuse heap in the compact black soil. On digging I discovered the singular soldier (2.5 mm. long, Fig. 11 *a*), which is unlike the soldier of any other Pheidole known to me except *Ph. absurda* Forel from tropical America. Forel's species, however, is larger and exhibits several other differences. The soldier of *Ph. lamia* is smooth and of the same honey-yellow color as the worker, except for the rough, brownish, Colobopsis-like anterior portion of its head. The abdomen of both soldier and worker has in its center a large dark spot, which is produced by the black contents of the stomach seen through the thin integument. The visual organs in both castes have undergone the usual reduction noticeable in hypogæic ants — there being scarcely more than a dozen facets in each of the small, emarginate eyes of the soldier.[1]

IV. Xenobiosis.

The inquilines, or guest ants (*Gastameisen*), constitute a group of considerable interest, since it is not improbable that these insects may ultimately give us some clue to the conditions that have led to the development of mixed nests from those of the double or compound variety. Unfortunately we know very little of the habits of some of the species that have been recorded as guest ants. So far as known the inquilines maintain their independent households, although they consort freely with their hosts and live with them on terms of mutual toleration, or even friendship. The best-known guest ant is the

[1] It is probable that several of our North-American species of Strumigenys are cleptobiotic. In a former paper ('00 *a*, p. 31) I recorded the occurrence of *S. louisianæ* in the nest of *Pachycondyla harpax*. While this paper is going to the press Rev. P. J. Schmitt writes me that "*S. pergandei* Emery, more than any other species of this genus, is almost always, at all events more frequently than not, to be taken in the nests of *Formica subsericea*, *F. exsectoides* or the slaveholders *F. rubicunda* and *subintegra* in the ground, and with *Lasius aphidicola* in rotten wood. There — after the fashion of *Solenopsis molesta* — it occupies a small chamber of its own, which connects with the galleries of the larger ants. These peacefully tolerate and scarcely notice their tiny neighbors."

European *Formicoxenus nitidulus*, which has been carefully studied by Adlerz ('84), Forel ('74, '86), Wasmann ('91), and Janet ('97). It is a singular fact that, notwithstanding all these valuable observations, the feeding habits of the Formicoxenus have never been observed. As this ant, in certain particulars, strikingly resembles *Leptothorax emersoni*, Janet's *résumé* ('97, pp. 54–56) of what is known concerning its behavior may be quoted before recording the little that is known concerning our American guest ants.

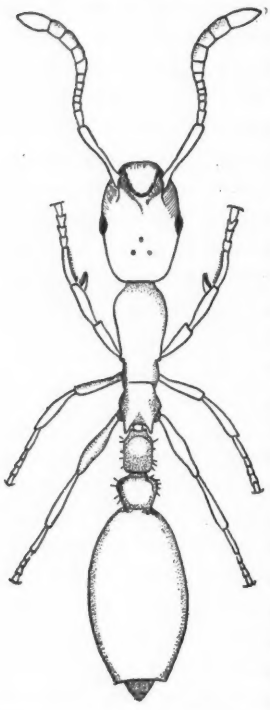


FIG. 12.— *Formicoxenus nitidulus* Nyl. Male (after Adlerz).

"*Formicoxenus nitidulus* is a pretty little species of very timid character. Forel found it to be a rare insect in Switzerland. I have several times taken small colonies of it at Beauvais. Wasmann mentions it as very common in Holland. Adlerz found it abundant in southern Sweden. It is, therefore, a north European species. The worker scarcely reaches a length of 3 mm., and the queen is but little larger. The male (Fig. 12), discovered by Adlerz ('84), is apterous like that of *Anergates atratulus* and like one of the male forms of *Ponera punctatissima*. Its shape, color, and the absence of wings make it difficult to distinguish from the worker. It may, nevertheless, be recognized from other external male characters. Its antennæ are more strongly recurved at their tips and are 12-jointed; *i.e.*, they have one more joint than the female phases (either queen or worker). In the abdomen five segments (the 7th to 11th) are visible from the exterior instead of four (segments 7 to 10) as in the females. The mandibles are smaller; the ocelli are well developed. The relations of *Formicoxenus nitidulus* to its host have been especially studied

by Adlerz ('84). Its colonies, usually consisting of a small number of individuals, may, however, be very populous at times. It establishes its nest in the very interior of the nest of *Formica rufa* or of *F. pratensis*. The small chambers which it there constructs and inhabits, together with its progeny, communicate by means of large openings with the galleries of the Formica nest. Wasmann ('91, p. 35) found a colony of Formicoxenus consisting of workers, males, queens, and young, inhabiting the cavity of an old cocoon of *Cetonia floricola*, a beetle which lives during its larval stages in the bottom of the nest of *Formica rufa*. *Formicoxenus nitidulus* often moves about among its hosts. The observations of Adlerz, Forel, Wasmann, and myself prove that these myrmecophiles are never met with outside of the nests of the *Formica rufa* and *F. pratensis*. They live in peace with their hosts, but they are not cared for by them, nor do they render them any service. Observers who have studied the behavior of this species have on exceptional occasions observed acts of a slightly hostile nature on the part of the two species, but these acts were without serious consequences. On one occasion, in one of my artificial nests, in which the ants had previously lived on good terms with one another, I saw a Formica touching a Formicoxenus with her antennæ and menacing her with her mandibles ; but she departed without even attempting to seize the inquiline. In the same nest I found a Formicoxenus which had seized the leg of a Formica in its mandibles and had died in this position. The Formicoxenus (Forel, '86, p. 134) are able, either by themselves or by carrying one another, to follow the files of their hosts when the latter move into a new nest. They also carry their progeny to the new nest. In the nests of their hosts they find shelter, warmth, and efficient protection from other ants, against which they would be unable to defend themselves. There they also find sustenance, but it has been impossible up to the present time to determine its nature."[1]

[1] In Emery's *Beiträge* ('95, pp. 271, 272), *F. nitidulus* is cited as occurring in North America. The specimens to which Emery refers were labeled "Rocky Mountains." But Emery (*in litteris*) has expressed grave doubts concerning the

13. **Xenomyrmex stollii** Forel (Fig. 13).

X. stollii is a small, smooth, dark brown ant, allied to the species of Monomorium. It is a native of Guatemala and was found, together with its larvæ and pupæ, living in a huge oak gall in company with a much larger ant, *Camponotus abscisus* Rog. More recently a subspecies, *floridanus*, of this same species was discovered at Lake Worth, Fla., by Mr. Pergande. (See Emery, '95, pp. 275, 276.) On this occasion the ants were living, unaccompanied by another species, in a hollow twig of *Xyderoxylon masticodendron*. Wasmann ('94, p. 163) expresses some doubt as to whether the Guatemala form really forms a mixed colony with the Camponotus, since the ants are members of different subfamilies; but he nevertheless regards this case as in a sense transitional to the mixed nest, since Xenomyrmex appears to build no nest of its own. From an inspection of our Texan oak galls, which are frequently inhabited by ants, I feel sure that nests of very small size on the plan

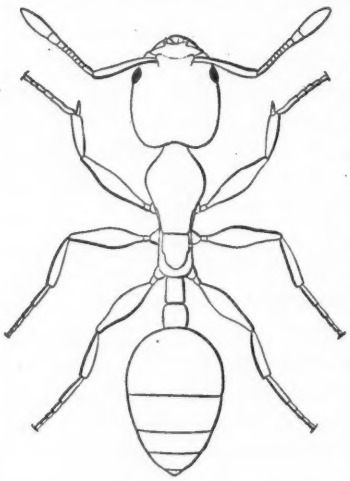


FIG. 13. — *Xenomyrmex stollii* Forel. Worker.

occurrence of Formicoxenus in this country. My own reference to this form as occurring at Colebrook, Conn. ('00, p. 48, footnote), is based on a wrong identification. The species there recorded is really *Leptothorax emersoni*, which in size, color, and superficial appearance resembles *Formicoxenus nitidulus*.

Two additional species of Formicoxenus have been recently discovered in Europe, and both have been described from female specimens only. *F. ravouxi* André ('96) was captured in a normal nest of *Leptothorax tuberum* Fabr., subsp. *unifasciatus* Latr., provided with fertile queens. The host of the other species, *F. corsicus*, described by Emery ('95 *a*, p. 12), is unknown.

Emery also describes (*ibid.*, p. 11) another ant, *Phacota noualhieri*, from a single specimen taken in a nest of *Monomorium salomonis*, var. *subnitidum*. Emery regards the new species as being in all probability parasitic or inquiline in its habits.

of the double nests of the *Formica rufa* and Formicoxenus could be formed even within one of these circumscribed vegetable growths. The guest ant could inhabit the central capsule (in which the gall fly passes its pupal stage), while the host ant might occupy the chambers dug in the ligneous substance of the gall. I am led to this supposition by finding that a new species of Leptothorax, which regularly nests in the *Holcaspis cinerosus* galls formed on the live oaks about Austin, prefers the small central capsule as a nursery. Here the single queen lives wedged in between the eggs, larvæ, pupæ, and a few workers, while the chambers of the gall are commonly tenanted by the bulk of the workers.

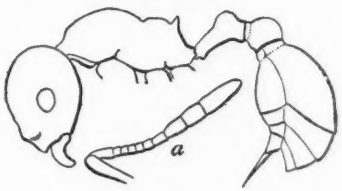


FIG. 14. — *Leptothorax* (*Dichothorax*) *pergandei* Emery (after Emery). *a*, antenna of same.

14. **Leptothorax (Dichothorax) pergandei** Emery (Fig. 14).

Our knowledge of this species, too, is extremely meager. It was described by Emery ('**95**, pp. 323, 324) from specimens taken as guests in a nest of *Monomorium minutum*, var. *minimum*, at Washington, D. C., by Mr. Pergande.

15. **Leptothorax emersoni** n.sp.

The Leptothorax described in detail in the first part of this paper may be included among the guest ants, although it certainly resembles in many respects the cases of dulosis and social parasitism.

UNIVERSITY OF TEXAS, AUSTIN, TEXAS.

(*To be continued.*)

ON THE OSTEOLOGY AND SYSTEMATIC POSITION OF THE ALCÆ.

DR. R. W. SHUFELDT.

SOME twelve or thirteen years ago I published several illustrated papers upon the osteology of the Alcæ, they having appeared in the *Journal of Anatomy* of London (Vol. XXIII, N.S.; Vol. III, October, 1888, pp. 1–39, Pls. I–V; January, 1889, pp. 165–186, Pls. VII–XI; April, 1889, pp. 400–427, Figs. 1–17 (text); July, 1889, pp. 537, 538, Figs. 1–8, and October, 1889, pp. 89–106, Pls. VI–VIII). In the text-figures and plates to these memoirs will be found reproductions of drawings of mine of the bones of a great many species of Alcæ, as *Alca torda*, *Plautus impennis*, Uria (two species), Synthliborhamphus, Cepphus, Brachyrhamphus, Lunda, Fratercula, Cyclorrhynchus, Simorhynchus, and others. In some cases several species of each are illustrated, there being upwards of one hundred figures in all. The descriptions are quite in detail, and taken in connection with the cuts and plates present accounts of nearly all the auks and puffins and their immediate allies known to science the world over. In fact, the only genera not thus treated are Pseuduria, Micruria, and Ceratorhyncha, and it is not likely that the osteology of any of these differs very much from that of known forms more or less nearly related to them, and certainly not to an extent to modify the present views of avian taxonomers upon the classification of the Alcæ. It will not, therefore, be necessary to reproduce much, if any, of that work in the present connection, and so far as the osteology of the extinct great auk (*Plautus impennis*) is concerned it has been very thoroughly described by numerous writers, and particularly by Sir Richard Owen and Mr. F. A. Lucas of the United States National Museum. To illustrate the present paper, however, I will offer a figure of the skeleton of the great auk, in order not

only to complete my series of illustrations of the skeletons of these birds, but also to bring before the readers of this paper the skeleton of a typical auk as a convenient reminder of the osteological characters of the bird forms here being considered. My space, therefore, will be principally occupied by a presentation of the various views of avian systematists on the position of the Alcæ in the system.

The auks and puffins, as is well known, constitute a very well circumscribed and distinct group of birds, with apparently no outlying forms, and, apart from *Plautus impennis*, no fossil remains of any species of them have as yet been discovered, or at least described. Dr. Sharpe records none in his *Hand-List of Birds* (1899, pp. 130–133).[1] Notwithstanding these facts, the opinions of the classifiers of birds are by no means unanimous on the question of the systematic position of the Alcæ. Professor Huxley, for example, grouped the Laridæ and the Alcidæ in one of his suborders, — the Cecomorphæ, — and said of the last-named family, "The Alcidæ in their pterylosis and other characters approach the penguins, especially through *Alca impennis*" (*Proc. Zoöl. Soc.*, 1867, p. 458); and Newton has remarked that "the affinity of the Alcidæ or auks (and through them the divers or Colymbidæ) to the gulls may be a matter beyond doubt, and there appears to be ground for considering them to be the degraded offspring of the former; but to the present writer it appears questionable whether the grebes (Podicipedidæ) have any real affinity to the two families with which they are usually associated; and this is a point deserving of more attention on the part of morphologists than it has hitherto received" (*Encycl. Brit.*, 9th ed., Vol. XVIII, art. "Ornithology," p. 45). Garrod, later on, who certainly entertained very peculiar notions about

[1] As this article goes to press I would say that a part of a fossil bone of an auk has been received by Mr. Lucas of the United States National Museum from a party in California, where it was found. This specimen I have been permitted to personally examine. It consists of the proximal moiety of a humerus that belonged to a species apparently as large as Plautus, but exhibiting even a more feeble development of the pectoral limbs. Mr. Lucas has described this specimen before the Biological Society of Washington, D.C., and his description will be published later on.

the affinities of birds, arrayed his Order IV, the Charadriiformes, between his Ciconiiformes (Order III) and his subclass Anomalogonatæ (Order I, Piciformes). The Charadriiformes were made to contain two cohorts (α and β), namely, the Columbæ and the Limicolæ, the latter being represented by the Charadriidæ, the Gruidæ, the Laridæ, and the Alcidæ. When one considers the birds he grouped in his Ciconiiformes and his Piciformes, such a classification is surely to be regarded more in the light of a taxonomical curiosity than to be taken seriously as a contribution to the *natural* classification of birds (cf. *Proc. Zoöl. Soc.*, 1874, p. 116).

As to the view entertained by Mr. W. A. Forbes on the position of the Alcæ, I have a number of letters from him on the subject, written to me from London, just before he left on his fatal trip to Africa, in which this question is referred to and set forth. These will be published in another connection by the present writer, together with others on various scientific matters of interest. Forbes's classification of birds was written out by him in his diary only four days before his death on the Niger, but it is more or less fragmentary, and I shall not discuss it here (cf. *Ibis*, 1884, p. 119).

Dr. P. L. Sclater, in his classification of birds, places the two families Colymbidæ and Alcidæ as alone constituting the group Pygopodes (Order XXI), inserting them in his scheme between the Tubinares and Impennes (Orders XX and XXII, respectively). (See *The Ibis* for 1880.) This is certainly at variance with Professor Huxley's views, though, as Dr. Sclater's Order XIX (Gaviæ) includes only the Laridæ, it agrees in one way with what Professor Huxley proposed, and that is, that the Laridæ, the Procellaridæ, the Colymbidæ, and the Alcidæ, grouped as families, were next nearest the penguins in their affinities.

Dr. Reichenow (1882) surely did not appreciate the value of the osteological characters of the Impennes (penguins) when in his scheme of classification for Aves (*Die Vögel der Zoologischen Gärten*) he placed the Spheniscidæ, the Alcidæ, and the Colymbidæ as the three families constituting his second order, the Urinatores. Such an arrangement distinctly differs

from that of Huxley and others, and cannot be sustained upon morphological grounds, which are the only true ones to be considered in the natural classification of animals of any kind. Coues and Ridgway, as representative authorities of the American Ornithologists' Union (1884–95), consider the Alcidæ to be a family of the order Pygopodes, arrayed with the Urinatoridæ in a suborder, Cepphi. Why a grebe (Æchmophorus) and a puffin (Lunda) should, as birds, be associated in the same order, is quite beyond the comprehension of the present writer, who believes that Professor Cope went equally wide of the mark when, in his classificatory scheme for Aves, he made an order, Euornithes, which is included in his superorder Eurhipiduræ ; and in the former, the Alcidæ fall within the suborder Cecomorphæ (cf. *Amer. Nat.*, October, 1889).

The late Professor William Kitchen Parker, in his admirable memoir *On the Morphology of the Duck and Auk Tribes*, says, on page 91: "I am under the impression that penguins never possessed quills, and that their adaptation to aquatic life and their great power of diving took place much earlier in their ancestral history than in the case of the auks and guillemots — birds that tend to become a sort of palearctic penguin but never quite lose the marks of their former adaptations to a more terrestrial life. I conceive of their ancestors in amphibious or limicolous birds, and I imagine the forefathers of gulls, plovers, rails — the auk tribe — as being very much alike and very nearly related. . . . All the penguins are alike in everything that is important; of the Alcidæ only one, *Alca impennis*, became transformed into the likeness of a penguin; the specialization of the family has been imperfect as compared with the penguins, and, as I believe, took place later in time" (*Cunningham Memoirs*, No. VI, Royal Irish Academy, Dublin, November, 1890).

A marked approach toward a natural classification of the several groups of birds I have been considering here was arrived at when Dr. Leonard Stejneger published his scheme in 1885 (*Standard Natural History*, Boston). In it the

arrangement proposed by this keen observer of morphological characters in animals is, in the case of the birds in question, as follows:

Superorder	Order	Superfamily	Family
(II) Impennes	(V) Ptilopteri		Spheniscidæ
(III) Euornithes	(VI) Cecomorphæ	Colymboideæ	Colymbidæ
		Heliornithoideæ	*Heliornis* (Heliornidæ)
		Alcoideæ	Urinatoridæ, Alcidæ
		Laroideæ	Stercorariidæ, Laridæ
		Procellaroideæ	Diomedidæ, Procellaridæ, Pelecanoididæ

From this it will be seen that the penguins (Spheniscidæ) are well separated from the grebes (Podicipedidæ: *auct.*) and these latter from the loons and auks, an arrangement which is a very natural one, based as it is upon an appreciation of the structural characters of the representatives of the families considered. Still, in the opinion of the present writer the association of the Urinatoridæ and the Alcidæ is too close, and not warranted upon morphological grounds.

Several years later, Dr. Hans Gadow (*Proc. Zoöl. Soc.*, 1892, p. 229) also proposed a "Classification of Birds," in which he attempted to employ all the known structural characters of the class Aves, as well as the previous opinions of all recognized authorities upon avian taxonomy. His position selected for the Alcæ is shown in the following scheme, abstracted from his arrangement as a whole:

16. Charadriiformes	I. Limicolæ	Chionididæ, Charadriidæ, Glareolidæ, Thinocoridæ, Œdicnemidæ, Parridæ
	II. Gaviæ	Alcidæ, Laridæ

In this scheme Dr. Gadow includes Attagis in the Thinocoridæ, and very widely separates the Charadriiformes, as constituted above by him, from the Sphenisciformes (8 of his scheme) and the Procellariiformes (9 of his scheme), — these last two groups having the Ardeiformes (10), the Falconiformes (11), the Anseriformes (12), Crypturiformes (13), Galliformes (14), and Gruiformes (15), standing between the Colymbiformes (7) and the aforesaid Charadriiformes (16). In other words, the loons and grebes are separated in this lineal arrangement from the group containing the auks and gulls, by the groups containing the penguins, the Tubinares, the Steganopodes, the herons, the Cathartidæ and Accipitres, the Crypturi, the fowls, and the Gruiformes.

This curious arrangement has doubtless been produced by the way in which the structural characters have been employed and contrasted. The entire scheme is highly unnatural in many particulars, as, for example, the relations indicated for the flamingoes to the storks, the two families alone representing the Pelargi, and this last group being associated with the herons and Steganopodes in an order, Ardeiformes. Between this last and the order Anseriformes stands the order Falconiformes, thus giving not the slightest suggestion as to the undoubted relation of the flamingoes to the anserine birds. This comes of the danger of using too many structural characters, and those characters of very different values and weight, and not properly contrasted. Such a practice will be sure to lead one away from the correct solution of the true relationships existing among birds in nature, taking the group as a whole, both existing and extinct, since birds were birds at all, in time; — and it is the expression of this in a taxonomic scheme of some sort or other that really we all are so desirous of perfecting. Sometimes, too, even the *lineal* scheme of so high an authority as Dr. Max Fürbringer is open to the same criticism, but not so when we come to examine the famous "avian tree" he constructed for us, and published in his great classic on the subject, *Untersuchungen zur Morphologie und Systematik der Vögel*, in 1888. With respect to the Alcæ, in

his lineal arrangement Professor Fürbringer classifies the family Alcidæ as follows:

- Charadriornithes (Ægialornithes)
  - Charadriiformes
    - Laro-Limicolæ
      - Charadrii
        - Charadriidæ
        - Glareolidæ
        - Dromadidæ
      - Chionididæ
      - Laridæ
      - Alcidæ
      - Thinocoridæ
    - Parræ . . . . . Parridæ
    - Otides . . . . . Œdicnemidæ, Otididæ

The relationships are exhibited more naturally in his "Phylogenetic Tree," where the offshooting of the various groups and subgroups can be much better appreciated, as they are, too, in the several sectional projections of the "Tree" he has given us.

Finally, passing over the several attempts of the late Mr. Henry Seebohm to classify the class *Aves* in so far as orders and suborders are concerned, and the earlier provisional schemes of Dr. R. Bowdler Sharpe, I come to the last one of the latter eminent authority as set forth in his *Hand-List of Birds*, published by the British Museum in 1899 (Vol. I, p. 130).

In this scheme the following arrangement has been proposed:

Orders	Families	Subfamilies
XII. Procellariiformes	Procellariidæ	Procellarinæ, Oceanitinæ
	Puffinidæ	Puffininæ, Fulmarinæ
	Pelecanoididæ	
	Diomedeidæ	
	Incertæ Sedis	(Hydrornis)
XIII. Alciformes	Alcidæ	Alcinæ, Fraterculinæ
XIV. Lariformes	Laridæ	Sterninæ, Rhynchopinæ, Larinæ
	Stercorariidæ	
	Incertæ Sedis	(Halcyornis)

There is a great deal to be said in favor of this classification, and it can be largely supported when the osteological characters presented on the part of the bird forms representing these various families are taken into consideration, as I have already demonstrated in my memoirs in the *Journal of Anatomy and Physiology* of London cited in a former paragraph of this paper. Dr. Sharpe is also quite correct when he places, as he does, in *The Hand-List of Birds* these three orders between the Charadriiformes upon the one hand and the Sphenisciformes upon the other.

Synopsis of the Osteological Characters of the Alcæ.

1. The superior mandible of the skull varies in its morphology. It may have its anterior portion elevated, convex, prominent, laterally compressed, and cultrate, terminating in a sharp hook, as in Alca, Fratercula, and Lunda; or, the superior mandible may not be hooked, the foregoing characters remaining the same, as in Cyclorrhynchus; or, it may taper gradually to a point, with the culmen roundly convex and not modified, as in Synthliborhamphus, Brachyrhamphus, Cepphus, and in Uria; or, finally, it may be broad at its base, and shortened, while its general characters remain the same.

2. With regard to the *supraorbital glandular depressions*, they may be entire, the upper orbital rim being finished off with an osseous emargination; and this associated with the *crotaphyte fossæ* either reaching the supraoccipital prominence or encroaching upon its summit, as in Alca and in Uria; or, the supraorbital glandular depressions may not be entire, the upper orbital rim being absorbed, producing wing-like postfrontals, and these characters associated with lateral crotaphyte fossæ, as in Fratercula, Lunda, Simorhynchus, Ptychorhamphus, Synthliborhamphus, Brachyrhamphus, and Cepphus. (It is in Brachyrhamphus that the crotaphyte fossæ are lateral.)

3. The extent to which the *interorbital septum* and the anterior wall of the brain-case ossifies varies greatly with age and is therefore an unreliable character. There is always more or less bony deficiency in these parts in the Alcæ.

In *Cyclorrhynchus psittaculus* the maxillo-palatines are nearly horizontal, while in Lunda they are nearly vertical, the angle for these bones varying between these two planes for the different genera, they having an obliquity of about 45° in Alca and Uria. The *vomer* also varies; in Alca and Uria it is never produced as a spine in front, while this is its normal condition in Simorhynchus and the Auklets generally. In certain Fraterculinæ it varies between these two extremes.

4. The *mandible*, though varying not a little throughout the group, presents in its general form the same fundamental characters in all. The angle is always recurved, the surangular is pierced by one large foramen, or two small ones; the ramal vacuity is usually closed by the splenial or dentary, and the sides of each ramus are more or less vertical, and the symphysis comparatively short. It is V-shaped when viewed from above.

5. As a rule, the Alcæ have the first pair of small free ribs on the fourteenth vertebra, followed by a better developed free pair on the fifteenth. In Brachyrhamphus and Synthiloborhamphus, the first pair of free riblets may be found on the thirteenth vertebra. Again, the number of ribs reaching the sternum through costal ribs varies, the variance depending upon a greater number of posterior pairs in some of the species. As we pass from the typical auks to the puffins the number of pairs of ribs decrease; for instance, *Alca torda* has *nine* pairs posterior to the first two free pairs, eight of which articulate with costal ribs, and they become long and sweeping behind. *Lunda cirrhata*, as a rule, has but *seven* corresponding pairs, and only six of these articulate with costal ribs; and they are comparatively shorter and less sweeping.

6. The *pelvis* offers us no definite characters that can be relied upon as constant, beyond the gradual change in its form. It is long and narrow in Plautus, Alca, and Uria, to become shorter and more spreading posteriorly as we pass to other genera.

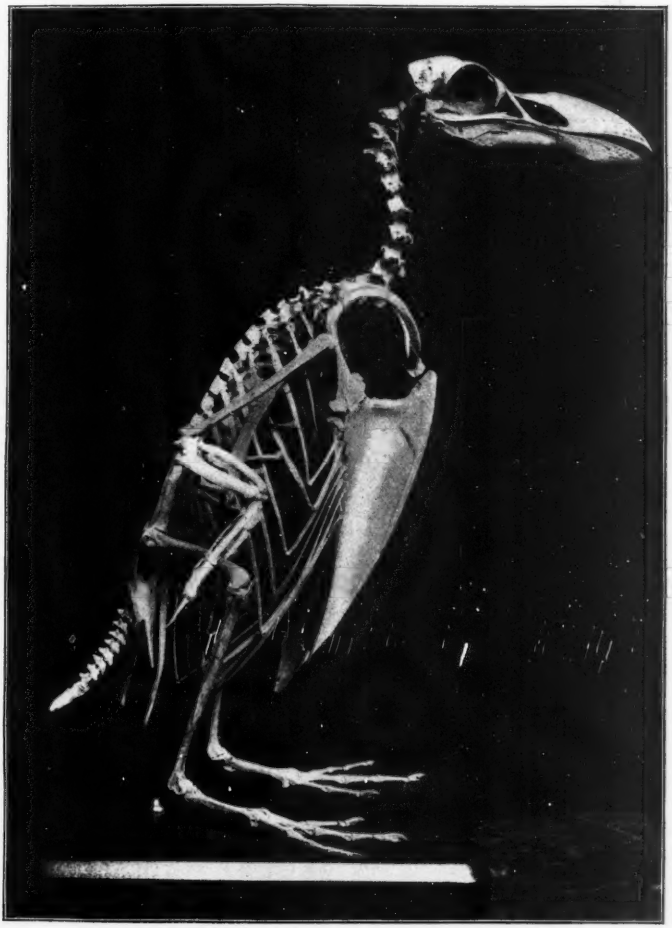
7. The number of free *caudal vertebræ* range from seven to ten, not including the pygostyle. I have found the latter number in a specimen of *Lunda cirrhata*.

8. When the xiphoidal extremity of the *sternum* is notched, it is 1-notched upon either side, but this is a very variable

character among the Alcæ. In some sterna a *small foramen may occur upon one side only*, and even this may be absent. Between these extremes a great variety of patterns is to be met with, as a notch upon one side and a foramen on the other, or both foramen and notch upon either side. The sternal body is long and narrow in Alca, Uria, Synthliborhamphus, Brachyrhamphus, and in the extinct Plautus, — those species, on the other hand, in which the sternum has a single notch on either side, and a single foramen within its inner border, the sternal body is rather broader anteriorly and more spreading behind, as in Cepphus, Lunda, and Fratercula. In Simorhynchus the sternum, having the same fundamental pattern, is long and narrow, with the xiphoidal extremity much produced beyond the carinal termination, being swelled and concave above and with one large, oblique, elliptical *foramen* on either side. This character also varies for different genera and species. The skeletons of the limbs do not appear to offer any constant characters. Full descriptions of the morphology of these parts, as well as the various forms of the sternum, are given in my previous memoirs, and they are illustrated by numerous cuts and figures, both in the text and on the plates.

On the Systematic Position of the Alcæ.

The Alcæ constitute a suborder of birds, in which is included but the single family Alcidæ. This family may be conveniently divided into two subfamilies, — the Alcinæ, containing all the true auks, and the Fraterculinæ, containing the puffins. As a group the Alcæ are connected upon the one hand with the Limicolæ through the Longipennes ; in other words, to the great snipe-plover group, and their allies through the gulls and their allies. On the other hand, they are connected with the Pygopodes and Impennes through the Tubinares, that is, through the petrel types with the penguins, the loons, the grebes, and their extinct allies, the toothed birds of the hesperornithine type of structure. Later on these relationships will be set forth in my scheme of classification of the class *Aves*, now in the course of completion.



EXPLANATION OF THE PLATE.

Skeleton of the Great Auk (*Plautus impennis*). Reduced. *Coll. U. S. National Museum*, No. 18,117. This skeleton is made up of the bones of numerous individuals.

CONTRIBUTIONS FROM THE ZOÖLOGICAL LABORATORY OF THE MUSEUM OF COMPARATIVE ZOÖLOGY AT HARVARD COLLEGE UNDER THE DIRECTION OF E. L. MARK. No. 124.

SOME METHODS FOR USE IN THE STUDY OF INFUSORIA.

A. W. PETERS.

The Yarn Siphon.

In accurate experimental work with Protozoa it often becomes desirable to separate them from the culture water in which they have grown and also from the solid débris, zoögloea, etc., contained in it. For one or several organisms this may be done by means of the "wash drop," as recommended by Eyferth (*Einfachste Lebensformen*, Braunschweig, 1900).

To obtain clean specimens in larger numbers, the following method has proved efficient for many kinds of Infusoria. From the culture jar a quantity of liquid containing the organisms and the débris naturally occurring there is removed with a pipette to a Stender dish. In this the organisms are well distributed by sucking up the liquid into, and forcing it out of, the pipette a few times. This is occasionally repeated during the subsequent procedure. A few pieces of woolen yarn about 10 cm. long are then laid parallel in a single strand, held in water, and pressed together (not twisted) until thoroughly wet. This yarn siphon is then placed with one end in the Stender dish, now elevated, the other end hanging down on the outside, a receiving vessel being placed underneath. Soon ciliated organisms pass over the siphon and are received into the lower vessel. The yarn acts as a filter as well as a siphon, keeping back solid matter and likewise dead organisms. From time to time fresh water is added to the Stender dish to replace that lost by siphoning. The process thus far yields the Infusoria in a large quantity of diluted culture water.

THE TUBE FILTER.

Numerous tests of the usual process of downward filtration with ordinary funnel and filter have shown that Infusoria (Paramœcia) can be removed from the inside of the filter only with the loss of a large proportion of their number, unless the filter be repeatedly rinsed. This results in a dilution, sometimes undesirable, and is at best an uncertain way of preventing the loss of organisms. To obviate these difficulties, I have employed another method.

To concentrate the organisms into a small amount of water, to remove the culture fluid entirely if desired, and to change the medium at will, I have devised the following apparatus, which may be called a "tube filter." One end of a short piece of wide glass tubing is closed by a piece of filter paper held in position by means of a rubber band binding it to the outer circumference of the tube. The process depends essentially upon the quality and area of the filter paper employed. For rapid work with a quantity of about 50 cc. contained in a Stender dish I have used a tube approximately 3 cm. in diameter and 6 cm. in length. This tube is held in a vertical position by a clamp fastened upon a ring stand. Under the tube, upon an elevated support, is placed the Stender dish, or preferably a deeper vessel, with the organisms. The tube is lowered until its paper diaphragm comes within a few millimeters of the bottom of the Stender dish. In the tube is hung a filled glass siphon with the lower end of its outer arm bent upward to prevent its running empty. As the water rises through the filter paper and into the tube it is removed by the siphon. More culture water with organisms, or any other fluid desired as medium, is then added to that in the Stender dish. The addition of the former effects concentration, as does also the final withdrawal of most of the liquid. This process of upward filtration leaves nearly all the organisms in the Stender dish when the tube is removed. By means of a supplying bottle, described below, carrying an air tube and a siphon, water may be added to the Stender dish as fast as it is withdrawn by the tube filter. This secures continuous renewal of the medium with practically no current.

The U-Cell for Renewable Media.

Another device, which I shall call the U-cell, serves much the same purpose as the tube filter, but on a smaller scale. It has the advantage of facilitating microscopic observation and of permitting more rapid change of medium.

To make this U-cell (Fig. 1) there are necessary two slides (best thin), a few rubber bands, and darning cotton of large diameter and close fibre. A piece one and a half times the length of the slides used is held at one end with the forceps and dipped into water until thoroughly wet, care being taken not to loosen its fibres or to make its diameter uneven by rough handling, although after dipping it may be drawn lightly between thumb and fingers to insure complete wetting. This is then laid lengthwise upon one slide (which is best placed across the top of an open Stender dish) in the form of a long U, and the other slide laid upon it. The ends of the U barely project beyond the parallel ends of the slides at the open end of the cell.

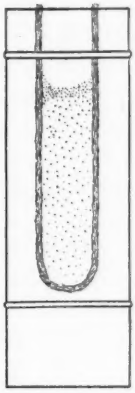


Fig. 1.

Two or three rubber bands — doubled so as to exert more pressure, if the smaller Infusoria are to be kept in it; otherwise not — are passed around the slides crosswise. This arrangement constitutes the U-cell. The darning cotton used should be of such a size as will cause the slides to be about 0.5 mm. apart when the rubber bands have been applied. This dimension and also the length of the U should be so regulated as to admit of the convenient use of a capillary pipette for the withdrawal of organisms. A shorter U should be obtained by the use of shorter slides, not by altering the proportions given above. Under the magnifier any selected individuals can be taken out. To fill the cell, water containing Protozoa is injected with a small pipette into the open end of the U, while the cell stands nearly vertical. A portion of the water will flow out through the cotton yarn, but capillary attraction will keep

sufficient water in it, even if the cell lies horizontal, as for microscopic examination. Moreover, this outflow affords a convenient method of removing the culture water and of renewing the medium at will without the loss of any Protozoa, if the cell is never permitted to overflow at its open end. A large number of organisms may be filled into it by repeated use of the pipette. Another method of filling the cell is to prepare a siphon consisting of a single wetted piece of woolen yarn, one end of which is inserted with a needle into the opening of the U to a depth of about 5 to 10 mm., the other end being put into the supplying Stender dish, elevated to permit the siphon to act. Over the single strand a continuous stream of Infusoria passes into the cell. These increase in numbers as the water passes through the U and escapes.

When it is desired to use higher magnification without removing organisms from the cell, an oblong cover-glass — *e.g.*, 22 × 44 mm. — may be substituted for the upper slide. Cover-glasses being too flexible, they must be braced in order to produce the even pressure upon the underlying thread necessary to retain small and active Infusoria. For this purpose slides are cut transversely into pieces about 5 mm. in width. At each end of the cover-glass one of these is laid across and a rubber band passed over it. At the open end of the U, as before, the ends of the slide and cover-glass must lie directly opposite each other. Such preparations can be conveniently preserved for a long time by standing them in an inclined position inside a low cylindrical vessel, the open ends of the U-slide projecting above the vessel and the lower ends resting against a bottle or a beaker, somewhat smaller than the vessel, placed in its center to serve as a stop.

The vessel may be filled with water to any desired depth. This method of preservation is applicable to organisms whose natural habitat is standing water.

THE U-CELL FOR CIRCULATING MEDIA.

The U-cell may also be used for a circulating medium, as shown in Fig. 2. The cells are placed in a cylindrical glass dish, with their lower ends resting in the angle of the dish.

They are inclined towards an inner vessel placed in the center of the first. The dimensions of the two vessels should be so selected that the upper ends of the cells come in contact with the inner vessel at about 5 mm. below its open end. From the inner vessel water is led by cotton-yarn siphons, S'', of appropriate size, into the cells. A constant-level glass siphon, S', is hung over the wall of the outer vessel. This prevents both overflow from the cells and the complete exhaustion of their water. The inner vessel is supplied with water from an elevated bottle placed near by and stoppered with a two-hole cork. One hole carries an air tube, A, extending to the bottom. The other carries a siphon tube, S, whose outer arm dips below the surface of the water in the

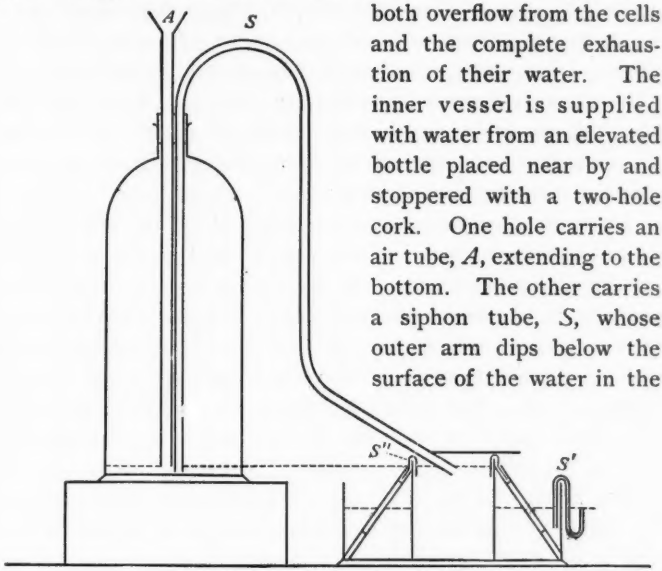


FIG. 2.

inner vessel. With the bottom of the bottle placed a little lower than the level desired for the liquid in the inner vessel, this level can be kept constant by raising or lowering the air tube of the supplying bottle. Then water will pass over the siphon only when the cells withdraw it from the inner vessel. The air tube may conveniently consist of a funnel tube, to be used also for filling the bottle with water. The inner vessel and its yarn siphons should be protected from dust by being covered with a glass plate whose edge is notched to admit the siphon tube. In siphoning, woolen yarn has been used wherever a rapid flow was desired, cotton yarn where a slower rate was needed.

USE OF ABSORBENT COTTON IN MAKING MICROSCOPIC PREPARATIONS.

Temporary or permanent preparations, permitting the frequent change of fluids under the cover-glass that is often required in micro-chemical work, can be made successfully by means of absorbent cotton. This method is very well adapted to the preparation of entire Infusoria. With the forceps a very small quantity of dry absorbent cotton, free from thick masses, is placed in position upon a well-cleaned slide. With a pipette a drop or two of water containing the Infusoria is placed upon the cotton. No more water should be used than can be absorbed by the cotton, which is then spread apart with two needles until the desired thinness of distribution of the fibres is reached. The cotton should occupy about the area of the cover-glass to be used. Both quantity and distribution must be learned by experience. A cover-glass is then lowered horizontally upon the preparation. If a hanging drop is to be transferred to the slide, the cotton is distributed while dry and the cover-glass lowered in the same manner. Two rubber bands, of such size as to exert some but not much pressure, are then passed around the cover-glass, one at each end. Fluids as desired are now passed under the cover-glass by adding them in drops at its upper end when the slide is placed in a more or less slanting position. The fluids emerging from the lower end of the cover-glass are permitted to run down the slide freely, or are guided down by means of a strip of filter paper. When the latter device is used, and with the larger Infusoria, the rubber bands may be removed after the passage of the fixing fluid, and all subsequent fluids slowly added in drops and entirely removed with filter paper, the slide in this case being kept in a horizontal position. In most cases the whole slide, held vertically and with rubber bands in position, may be alternately dipped into and raised out of the fluids to be applied ; but balsam had better be added in drops, as above described.

Finally the rubber bands are removed. The cotton properly used is a sufficient mechanical obstruction to prevent the

washing away of any organisms once placed within its meshes. Far less time and care, consistent with the safety of the preparation, are necessary than in the common method of making preparations "under the cover-glass" with the object lying free. At any stage in the process examination is convenient. The preparations can also be stored in the alcohols, etc., if desired. Owing to the use of dry cotton and the horizontal lowering of the cover-glass, the organisms are caught *in the meshes* of the cotton, seldom under or over its fibres. But few if any organisms need be lost, either in this procedure or subsequently. Success depends upon a proper adjustment to each other of the size and quantity of the materials used, and this can be accomplished after a few trials.

CAMBRIDGE, May, 1901.

NOTES ON A SMALL COLLECTION OF MAMMALS FROM THE LIU KIU ISLANDS.

OUTRAM BANGS.

THE following notes are on a small collection of mammals from the southern or Yayeyama group of the Liu Kiu Islands, recently acquired by the Museum of Comparative Zoölogy from Alan Owston, Yokohama. The collection was made by Ishida Zensaku in 1899, and comprises but four species, one of which is here described as new.

Our knowledge of the mammalian life of the Liu Kiu Islands is still very imperfect, and apparently but one other mammal — *Caprolagus furnessi* Stone[1] — has been recorded from there. This hare, and the bat here described, however, are additional evidence of the faunal relationship of these islands and Himalaya.

Sus sp.

One specimen of a young pig in the spotted and striped pellage, skull broken. Taken in the island of Ishigaki, April.

Crocidura (Pachyura) cærulea (Kerr).

Three skins with skulls, from Ishigaki, April and June. This shrew is said to be carried about in vessels like the house mouse. It certainly has an immense range throughout which it does not appear to vary.

Pteropus dasymallus Temm.

One adult skin with skull, from Ishigaki, March. Though originally attributed to Japan, this woolly bat is probably confined to the Liu Kiu Islands. Late research has failed to discover it in Japan, while it is known to be common in the islands.

Hipposideros turpis[2] sp. nov.

Three specimens, skins and skulls, from Ishigaki, May 10.

Type: From Ishigaki Island, southern group of Liu Kiu Islands, adult ♀ No. 10003, Coll. of Mus. of Comp. Zoöl. Collected by I. Zensaku, May 10, 1899.

[1] *Proc. Acad. Nat. Sci. Phila.*, Sept. 27, 1900, pp. 460–462.

[2] *Turpis*, ugly, unsightly, — on account of the hideous faces of these bats.

Characters: Most nearly related to *H. armiger* and *H. swinhoei*, but much smaller than either; vertical ridges on erect portion of nose leaf well developed and free edge of horseshoe entire, characters which agree with the large *H. armiger* and *H. swinhoei;* and not with *H. pratti* and the small *H. leptophylla*, the only other known species with erect portion of nose leaf narrower than horseshoe.

Color and fur: Fur long and fluffy, about 12 mm. long in middle of back; confined to body, and not extending on the membranes; on humerus it extends not quite to middle; on ear it covers a little more than the basal third, and on inner margin in front it extends upward, sparsely, nearly to the top; in Nos. 10003 and 10004 the basal portion of the fur on back and whole length of fur on lower surface is pale, dull cinnamon; on lower back and rump the tips of the hairs are much darker — nearly seal brown; No. 10002 has the under fur darker than in the other two specimens and much more drab in color.

Ears: The ears are large, very broad at base, and tapering abruptly from behind to a point; posterior surface roughened by many (about eleven) distinct cross ridges.

Muzzle and chin: Arrangement of nose leaf, horseshoe, etc. (so far as can be judged from dry specimens), nearly as in the large *H. armiger*, *i.e.*, erect portion of nose leaf narrower than horseshoe; vertical ridges on erect portion of nose leaf well developed; free edge of horseshoe entire.

Measurements: (All external measurements are from the dried specimens.)

Number	Sex	Total Length	Tail Vertebræ	Tibia	Foot	Forearm	Longest Finger	Ear from Meatus	Ear from Crown	Width of Ear
10002	♀	92	36	31	15.5	66	94	25	20	20
10003	♀	95	34	31	15	67	97	24	20	20.5
10004	♂	90	28	31	15	68.5	95.5	26	21	20.5

Skull: No. 10002 ♀, greatest length, 25.2; occipitonasal length, 21; zygomatic width, 13.6; length from front of canine to back of last molar, 10; length of mandible, 17.2. The skulls of all three specimens are imperfect, the basal and posterior portions, including the bullæ, having been cut away. The remaining portions agree closely with the skull of *H. armiger*, as do the teeth, except in being very much smaller.

I am indebted to Mr. Gerrit S. Miller, Jr., for assistance in comparing this bat with specimens in the National Museum.

Museum of Comparative Zoölogy,
Cambridge, Mass.

CONTRIBUTIONS FROM THE ZOÖLOGICAL LABORATORY OF THE MUSEUM OF COMPARATIVE ZOÖLOGY AT HARVARD COLLEGE. E. L. MARK, DIRECTOR. No. 125.

A CASE OF INCOMPLETE DUPLICATION OF PARTS AND APPARENT REGULATION IN NEREIS VIRENS SARS.

C. W. PRENTISS.

ALTHOUGH during the past few years numerous instances of complete bifurcation have been recorded in various annelids, I know of no case where intermediate conditions, or incomplete duplication of parts, have been observed. Among several hundred specimens of Nereis collected for class dissection in November, 1899, an individual was discovered apparently exhibiting an abnormality of this kind, and it was therefore deemed worthy of special study and a brief description.

The specimen we are to describe (Fig. 1), a sexually mature male, was collected at the mouth of the Saugus River near Lynn,

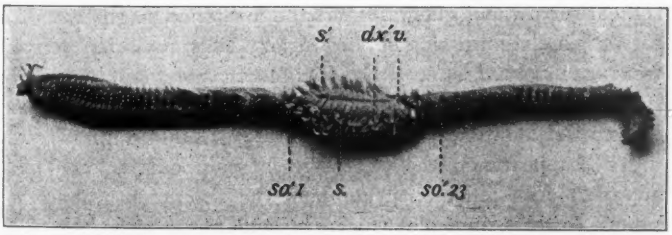


FIG. 1. — View of the left side of an abnormal Nereis, showing the interpolated region. (Natural size.) *dx.'*, right abnormal parapodium; *s.*, left normal parapodium; *s.'*, left abnormal parapodium; *so.'1*, first abnormal metamere; *so.'23*, last abnormal metamere; *v.*, posterior limit of the abnormal ventral region.

Mass. It measured 11.5 cm. in length when fully extended, and, except for the region near the middle of its body, was perfectly formed externally. The variation from the normal was, unfortunately, not observed until after the worm had been killed

by the ordinary method employed for laboratory material, and as a result the preservation of the tissues was not of the best. After photographing the animal from the left or abnormal side, three entire metameres from different points along the abnormal region were carefully removed by free-hand sectioning, mounted in balsam, and studied as whole preparations. The remainder of the worm was then imbedded in paraffin and a series of transverse sections obtained which enabled one to trace the different organs through the entire length of the specimen.

The abnormality, as seen in Fig. 1, is confined to twenty-three median somites. Not only is the diameter of the body much greater in this region than it is either anterior or posterior to it, but the number of parapodia to each segment is also increased. An extra pair of appendages is present on the forty-first metamere, or first abnormal somite (Fig. 1, *so.' 1*), of the worm. Immediately anterior to this somite there is evidence of a cicatrix ; the fortieth metamere, however, is apparently normal, and the interpolated parts make their appearance abruptly and in a fully developed condition. Looking at the left side of the animal, as in Fig. 1, three series of parapodia are seen. Two of these rows (*s.* and *dx.'*) are closely approximated and ventral in position ; the third set (*s.'*) is dorsal and separated from the other two by a region which, from its longitudinal furrow and general external appearance, might be taken for the true ventral side of the worm. This condition persists from the forty-first to the fifty-fourth metamere inclusive (fourteen somites), the pseudo-ventral region gradually becoming smaller and finally disappearing at *v.* As a natural result of its disappearance, the two series of parapodia (*s.'* and *dx.'*) approach each other until at about the seventeenth abnormal somite (*v.*) the appendages *s.*, *dx.'*, and *s.'* are close together. Parapodia *s.'* and *dx.'* of this metamere are much smaller than *s.*; their size is further reduced in the next six metameres, and in the twenty-third the last evidence of abnormality is to be observed. Externally at least, the somite segments of the animal are normal.

Examination of complete metameres in transverse section shows better the relations of the external parts and at the same

time brings out the structural conditions of the internal organs in the abnormal region. In the sixth abnormal metamere (Fig. 2) the two pairs of appendages are arranged symmetrically, *dx.* and *s.'* being lateral and in normal position, while *s.* and *dx.'*, placed back to back, project downward, or in a normal ventral direction. But there is apparently a well-developed ventral region on either side of these parapodia (*s.* and *dx.'*). At first glance it is difficult to tell which is the normal ventral side and which the interpolated part. In each

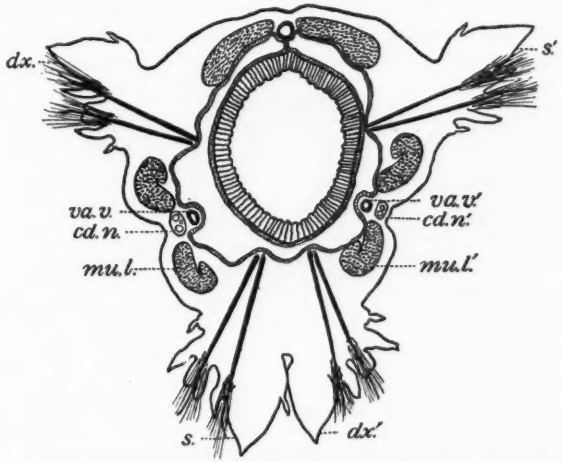


FIG. 2. — View of the anterior face (somewhat diagrammatic) of a transverse section of the sixth abnormal somite. (× 6.) *cd.n.*, *cd.n.'*, nerve cords; *dx.*, right normal parapodium; *dx.'*, right abnormal parapodium; *mu.l.*, *mu.l.'*, longitudinal ventral muscles; *s.*, left normal parapodium; *s.'*, left abnormal parapodium; *va.v.*, *va.v.'*, ventral vessels.

region there is a well-formed nerve cord (*cd.n.*, *cd.n.'*), flanked by a pair of longitudinal muscles (*mu.l.*, *mu.l.'*). The slightly smaller size of the parts on the right of the figure (the left side of the worm) is the main indication that this portion has been interpolated.

On examining the parapodia of this somite more minutely, we find that they are all normal in every part. Indeed, *dx.* and *s.'* might be taken for the normal pair, if *s.'* and *dx.'* were not slightly smaller than *s.* and *dx.* That these latter, however, are the normal appendages is plain from the conditions found

in the eighteenth abnormal somite (Fig. 3). At this point the ventral longitudinal muscles and nerve cord of the abnormal side have disappeared, and the parapodia *s.'* and *dx.'* are in close proximity, their inferior ligulæ nearly touching each other. They are now noticeably smaller than in Fig. 2 ; *s.* and *dx.*, on the other hand, have remained constant in size, but *s.*, no longer projecting ventrally, has swung around into a more lateral position on the left side of the median plane. As a result, the ventral surface of the animal is now more nearly parallel to the dorsal surface. Except for the absence of ventral cirri, *s.'* and *dx.'* still possess all their normal parts, but the relative size of

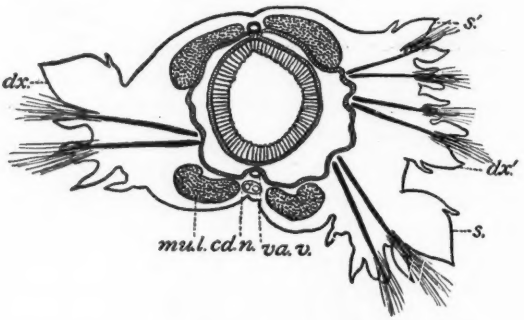


FIG. 3. — View of the anterior face of a section through the eighteenth abnormal somite and its appendages. (× 6.) *cd.n.*, nerve cord; *dx.*, right normal parapodium; *dx.'*, right abnormal parapodium; *mu.l.*, longitudinal ventral muscles; *s.*, left normal parapodium; *s.'*, left abnormal parapodium; *va.v.*, ventral blood vessel.

these parts is such as is characteristic of parapodia which are in process of development, rather than of fully formed appendages. This condition of arrested development is most noticeable in the ligulæ of the dorsal rami, which are disproportionately small as compared with those of the normal appendages of this metamere.

Tracing this same series of appendages (*s.'* and *dx.'*) back into the twenty-first abnormal somite (Fig. 4), they appear still further reduced. In appendage *dx.'* the dorsal ramus is small, and its inferior ligula is wanting. The ventral ramus is apparently represented by only the inferior ligula and aciculum. Appendage *s.'* is even more rudimentary, being represented by

only two projections, both of which belong to the dorsal ramus; the smaller is the dorsal cirrus, and the larger one the superior ligula of the dorsal ramus. Both acicula, as well as the ventral ramus, are wanting. In the third metamere posterior to this section, as we have seen from an examination of the exterior, the normal structure is once more regained.

Throughout the abnormal region the musculature of the body wall and that of the appendages are well developed in the interpolated portion. In the body wall of the interpolated part circular, longitudinal, and oblique muscles are found. The circular band is continuous with that of the normal portion of each metamere. The supernumerary longitudinal muscles

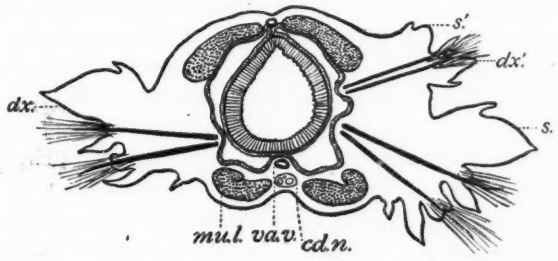


FIG. 4. — View of the anterior face of a section through the twenty-first abnormal somite and its appendages. (× 6.) *cd.n.*, nerve cord; *dx.*, right normal parapodium; *dx.'*, right abnormal parapodium; *mu.l.*, longitudinal ventral muscles; *s.*, left normal parapodium; *s.'*, left abnormal parapodium; *va.v.*, ventral blood vessel.

(Fig. 2, *mu.l.'*) have in cross-section the peculiar kidney shape characteristic of the normal longitudinal ventral muscles. They appear as small strands of fibres in the first abnormal metamere, and are attached to the circular muscle fibres of that region. They attain their greatest development in the next few somites, and after extending back through fifteen metameres are gradually reduced in size and finally disappear. Sets of oblique muscles are also found in those segments in which the extra, ventral longitudinal muscles are present. Parapodial muscles are attached to the proximal ends of the acicula, as is usual in normal appendages.

The intestinal canal shows no particular irregularity of form. There is no sign in the abnormal metameres of even partial division, but its size is remarkedly increased throughout this region.

Immediately above the abnormal nerve cord (*cd.n.'*) is an extra ventral blood vessel (Fig. 2, *va.v.'*). Beginning in the second interpolated somite, it can be traced back through the twelve succeeding metameres. Anteriorly it is connected by branches with the normal dorsal and ventral blood vessels and gives off ramifications to the organs of the interpolated region. Posteriorly there is no such direct communication with the normal blood vessels, and twigs from the normal vessels supply a portion of the blood to the extra parts in this region. In the last seven or eight abnormal somites this ventral vessel is absent and the interpolated parts receive their entire blood supply through small branches from the normal vessels. In each somite throughout the abnormal region a large branch of the dorsal blood vessel runs around the *left* side of the intestine directly to parapodium *s.*, passing the interpolated parts. As its main trunk enters this appendage it gives off a good-sized twig to *dx.'* Parapodium *dx.'* thus receives a better (double) supply of blood than *s.'*, and Figs. 3 and 4 show that *dx.'* is also better developed than *s.'*

The abnormal nerve cord (Fig. 2, *cd.n.'*) shows several interesting peculiarities. It has no direct connection with the main nerve cord, and it is normally situated with reference to the interpolated parts, lying between the two supernumerary longitudinal muscles. Its anterior end is found in the second abnormal metamere, whence it can be traced back through fifteen somites. Like the normal cord, it is supported by a network of neuroglia tissue, the whole being enclosed in a fibrous neurilemma sheath, which is thicker at the anterior than at the posterior end. A transverse section through this cord in the region of the third abnormal metamere exhibits the conditions shown in Fig. 5. There are eight small masses of neuropil, surrounded ventrally and laterally by groups of large

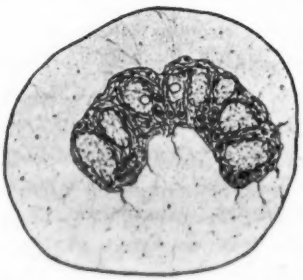


FIG. 5. — View of the anterior face of a transverse section through the anterior part of the abnormal nerve cord. (Dorsal is up in the figure.) (× 60.)

unipolar ganglion cells. The ganglionic masses can be followed continuously through three metameres. Four pairs of large nerves are given off from this portion of the cord to the supernumerary parapodia and the body wall. This ganglion measured 0.6 mm. through its widest part, which is 0.2 mm. more than the greatest diameter of any normal ganglion from the same region. There is thus an evident centralization of nerve substance at the anterior end of the abnormal cord, comparable perhaps to the centralization found in the subœsophageal ganglion of the normal nervous system. Throughout the remainder of the interpolated nerve chain there are two longitudinal connectives with a ganglionic enlargement in each of the twelve succeeding metameres. Fig. 6 is a transverse section through one of these ganglia. The connectives and ganglia are small, taper gradually at the posterior end, and terminate independently. Three of the ganglia averaged 280 μ in greatest diameter, while the longitudinal connectives varied from 300 μ, at the anterior end of the chain, to 125 μ, near the posterior end. The normal connectives and ganglia of the same region measured respectively 300 μ and 400 μ in diameter. Five pairs of nerves are given off latero-ventrally from each ganglion and connectives to the adjacent metameres. This agrees with the number of pairs innervating each normal somite of the worm. In addition to their small size the connectives present another peculiarity in the absence of the three giant fibres, which are such conspicuous structures in the normal cord.

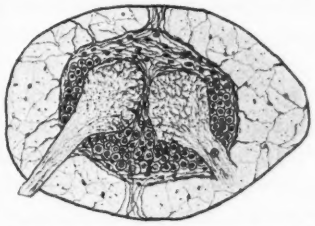
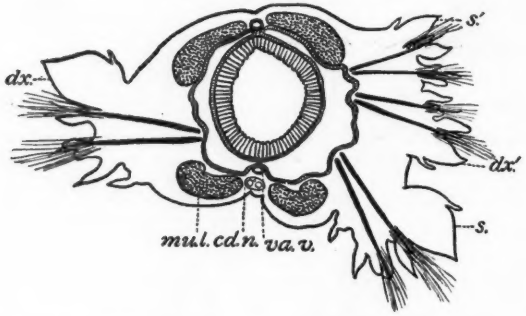


FIG. 6. — Anterior face of a transverse section through the seventh abnormal ganglion; showing neuropil, ganglion cells, and a pair of parapodial nerves. (× 60.)

From the above description of the animal we find (1) that the abnormality is serial in its occurrence, makes its appearance abruptly, and extends through twenty-three somites; (2) interpolated in each of the first twelve abnormal metameres is a pair of appendages, together with all the organs which, in the normal animal, are included ventrally between the parapodia;

in the eighteenth abnormal somite (Fig. 3). At this point the ventral longitudinal muscles and nerve cord of the abnormal side have disappeared, and the parapodia *s.'* and *dx.'* are in close proximity, their inferior ligulæ nearly touching each other. They are now noticeably smaller than in Fig. 2 ; *s.* and *dx.*, on the other hand, have remained constant in size, but *s.*, no longer projecting ventrally, has swung around into a more lateral position on the left side of the median plane. As a result, the ventral surface of the animal is now more nearly parallel to the dorsal surface. Except for the absence of ventral cirri, *s.'* and *dx.'* still possess all their normal parts, but the relative size of



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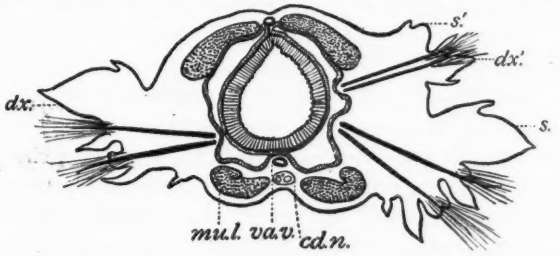

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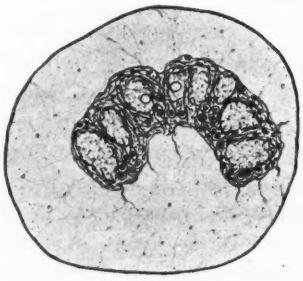

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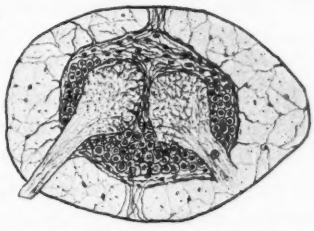

FIG. 6. — Anterior face of a transverse section through the seventh abnormal ganglion; showing neuropil, ganglion cells, and a pair of parapodial nerves. (× 60.)

From the above description of the animal we find (1) that the abnormality is serial in its occurrence, makes its appearance abruptly, and extends through twenty-three somites; (2) interpolated in each of the first twelve abnormal metameres is a pair of appendages, together with all the organs which, in the normal animal, are included ventrally between the parapodia;

(3) within the next eleven somites the supernumerary parts gradually diminish in size and disappear; (4) the presence of a slight cicatrix, anterior to the first variable metamere, indicates that the abnormality resulted from an injury received at a point where the development of new somites was in progress.

The structural conditions which we have found to exist in this instance of partial duplication of parts throws light on the cases of complete bifurcation of the posterior end which have been frequently observed in annelids.

Among the Lumbricidæ Robertson ('67) figures and describes a specimen of *Lumbricus terrestris*, the body of which is forked at the eighty-fifth somite. Each portion of the fork begins with a perfect somite, and both are borne on a single large metamere. A branch of the bifurcated intestine, of the chief blood vessel, and of the nerve trunk, is contained in each terminal, and the sexual organs are also fully developed.

Bülow ('83), experimenting upon the regeneration of lost parts in *Lumbriculus variegatus* Gr., discovered among the animals which he operated upon several specimens possessing two well-formed tails. In one individual 5.5 cm. long the so-called tails were 1.75 cm. in length.

Bell ('87) noted a case of bifurcation at the posterior end in *Nereis pelagica*, but gave no detailed description.

Andrews ('92, '94) has devoted special study to bifid annelids. His first paper ('92) reviews the literature of the subject, and describes among polychætes, in the family Syllidæ, an individual of the species *Procærea tardigrada* Wb., which possessed two tails of nearly equal length. In his second paper ('94) he figures and describes two cases of the bifid condition in the oligochæte *Allolobophora fœtida*, and eight cases of a similar abnormality in the polychæte *Podarke obscura*. In the ten specimens described there was at the posterior end complete duplication of the main axis of the body and all its appurtenances. The only exception was an earthworm in which the digestive tract was absent in one of the tails. In five out of eight specimens of Podarke one of the terminal parts had no

direct nervous connection with the hind end, although a well-formed nerve cord was present in the tail itself. This condition of the nervous system thus closely resembles that which we have here described in Nereis.

Andrews thinks that the balance of evidence favors the conclusion that these cases of bifurcation may be produced in the adult by traumatic interference ; all the conditions may be thus explained, and some can be accounted for in no other way. But though he performed many regeneration experiments on both earthworms and Podarke, no duplications were produced. This, however, he does not consider astonishing, as examples of bifurcation are extremely rare under natural conditions, although loss of parts followed by regeneration is constantly taking place.

Andrews accounts for the independent condition of the nerve cords in the bifurcated specimens of Podarke by assuming that the short isolated part represents a piece formerly connected with the main nerve cord, which has failed to reunite with it. To quote his own words : "We naturally suppose here that a wound has healed over in such a fashion that the old nerve cord does not reunite, but that the distal end remains as an isolated stump, while the proximal end grows down into the new terminal that is formed, abnormally, in place of the injured tissue, or at the place of injury to the tissue of the normal terminal."

The conditions which we have described in the interpolated nerve cord of Nereis do not allow the application of Andrews's assumption. The abnormal nerve chain does not extend into the normal somites anteriorly, but is wholly restricted to the interpolated region, and must therefore have been formed after the assumed injury to the worm ; then, too, its finer structure differs from that of the main nerve cord, more especially at the anterior end, where we should expect to find it most closely resembling the normal cord if it represented a detached portion of it. In this Nereis, therefore, the interpolated nerve cord undoubtedly developed as an independent structure.

It is well known that in nearly all annelids the cells of each metamere behind the head region possess the latent power

of regenerating new somites in case of their accidental loss. *Syllis ramosa*, a remarkable annelid described by M'Intosh ('85), is not only capable of forming terminal somites, but also of producing lateral buds. The branches of the main axis thus formed may again bud, forming a complex system, any ultimate tip of which may be constricted off and develop into a sexual animal. In this case a portion only of a somite may give rise to a perfect individual. As Andrews has pointed out, lateral budding in Syllis, and bifurcation of the posterior end in Lumbricus, are undoubtedly merely different manifestations of the same phenomenon. In the budding, duplications of the main axis are formed at successive periods ; in bifurcations of the body, the duplications are formed simultaneously. In both cases a sexual animal exhibits the power of reproducing itself by means of a vegetative process.

It is easily conceivable that, as a result either of injury to the anal somite, or loss of caudal metameres, two regions of regeneration might be formed instead of one. If these formative areas are entirely independent of each other, their continued growth would produce a bifurcated condition, and Bülow ('83) occasionally found this to be the case in regenerating earthworms. If, however, the separation of the two areas of regeneration is incomplete, the duplication of the new metameres would be only partial. Thus, in the Nereis which we have described, injury to the anal somite (when it was the forty-first metamere of the worm), or accidental loss of a few somites posterior to the fortieth, might, on regeneration, have produced the incomplete duplication of the metameres. That this may be the true explanation of the abnormality seems very probable, but further (experimental) evidence is needed to demonstrate it beyond a doubt.

It would seem a more difficult task to account for the gradual diminution in size and final disappearance of the interpolated parts. The changes which brought about such a return to the normal condition could have taken place only in the anal metamere, for it is there that the fundament of each new somite is laid down. The gradual process of reconstruction which must have taken place in the formative tissue may be compared

to the phenomenon of regulation observed by Rand ('98, '99), by which the more primitive cœlenterate, *Hydra viridis*, rids itself of supernumerary structures produced by abnormal regeneration. This inherent regulative power may have been assisted in the worm by arrested development of the interpolated parts due to a deficient blood supply. The structure of the abnormal parapodia, as we have seen, warrants the assumption that their development is incomplete, and the defective condition of the vessels supplying these appendages strongly indicates that lack of sufficient nourishment was the cause. Such a defect in the vascular system, however, could merely aid in the reduction of the abnormal parts; their total disappearance must be due primarily to the profound regulative changes which took place in the reproducing anal metamere.

Such a strong inherent tendency toward the production of a constant and normal condition undoubtedly accounts for the infrequent occurrence of abnormalities in regenerating worms. In most cases of injury, where regulation becomes necessary, the process is probably completed before the formation of new somites begins. When, on account of a specially serious injury, the process is delayed, partial duplications may be formed, but the regulative changes may still go on to completion and the normal condition be finally established, as in the present case. If, however, the traumatic influence is so profound as to give rise to separate regions of regeneration, regulation may take place in each and produce two normal series of metameres, but an abnormal bifurcated worm.

From our description of this single case of abnormality in Nereis, and comparison of its structure with that found in bifid Polychæta, we may conclude :

1. That a single metamere of a polychæte annelid may give rise to a complete or partial duplication of the main axis of the body.

2. The production of these abnormalities in all probability takes place in the post-embryonic worm, and is due to traumatic stimulus.

3. The supernumerary, and in some cases useless, parts thus formed may be gradually suppressed by regulative changes

which take place in the formative segment and tend to restore it to the normal.

In conclusion I wish to express my thanks to Professor E. L. Mark for most helpful suggestion and criticism.

CAMBRIDGE, MASS., May 24, 1901.

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SYNOPSES OF NORTH-AMERICAN INVERTEBRATES.

XIV. The Hydromedusæ — Part III.

CHARLES W. HARGITT.

Medusæ.

The Medusæ (medusoids, medusiform persons, gonophores, gonozooids) of this class of cœlenterates may be designated as in general of the form of a more or less transparent bell, or saucer-shaped disk, varying in size from the almost microscopic to organisms of fifteen inches or more in diameter.

The comparison of the medusa with a bell is fairly good, its body being similar in form in typical cases to the body of the bell, the manubrium corresponding to the clapper. A similar comparison with an umbrella is almost equally appropriate, if not superior. In this case the body of the medusa would correspond to the extended disk of the umbrella, the manubrium to the handle, and in some respects the radial canals are comparable with the ribs of the umbrella, while the numerous tentacles of some species are somewhat comparable with the marginal fringe often seen upon a lady's parasol. In further keeping with this comparison the outer, aboral portion of the medusa bell has been designated as the exumbrella, the inner, concave portion of the bell as the subumbrella. The mouth is located at the terminal, pendent portion of the manubrium, and through the tubular canal as an œsophagus communicates with the gastric pouch or stomach, from which radiate the gastric or chymiferous canals, by means of which the digested food matter is distributed over the body and through the circular or circumferential canal to the marginal organs.

At first sight there might seem to be little in common between the medusa and hydranth, either as to form, structure,

habit, etc.; but a closer scrutiny will reveal so intimate a fundamental likeness in all essentials as to demonstrate clearly the homological equivalent of every feature, some of the accessory or sensory structures alone excepted; and since these are not constant features they may clearly be disregarded in the comparison. Differences as to form and habits may be considered as adaptations to the characteristic functions of a free and motile organism.

In keeping with the synopsis of orders already given, that of the several families and genera of Medusæ will be taken up in their respective order.

ANTHOMEDUSÆ.

The Anthomedusæ are generally of more or less hemispherical form or sometimes of an elongate or subconical outline. All are possessed of a definite, muscular velum; sensory organs or ocelli borne on bulbs located at the bases of the tentacles, about which there is usually a colored pigment rendering them quite conspicuous, are usually present; otocysts are not present. The radial canals are generally four in number, rarely six or eight; gonads are developed and borne on the walls of the manubrium.

SYNOPSIS OF FAMILIES.

I. CODONIDÆ. Mouth-opening simple, devoid of tentacles or lobings; gonads not radially divided, but forming a circular, continuous tissue about the manubrium; marginal tentacles unbranched.

II. TIARIDÆ. Mouth-opening provided with simple or frilled oral lobes; with four or eight distinct manubrial gonads; marginal tentacles unbranched.

III. MARGELIDÆ. Mouth-opening surrounded with four or more simple or branched oral tentacles; four or eight manubrial gonads; marginal tentacles unbranched.

IV. CLADONEMIDÆ. Mouth-opening rarely simple, usually provided with oral lobes or tentacles; marginal tentacles variously feathered or branched.

Key to the Genera.

CODONIDÆ.

A. With two or four marginal tentacles, equally developed.

1. Tentacles and manubrium long and slender, the latter extending much beyond the velum; bell hemispherical . . . . Coryne
2. Tentacles rather short, stout, and capitate; manubrium extending but slightly beyond velum; bell conical . . . . . Dipurena
3. Tentacles rather stout and closely coiled, bell elongate hemispherical and with eight rows of nematocysts . . . . . Ectopleura
4. Tentacles only two at liberation, four in maturity . . Hydricthys
5. Tentacles very rudimentary, bell oblong . . . . . Pennaria
6. Bell hemispherical, with slight conical apical projection, tentacles two, often coiled within bell when disturbed . . . Perigonimus

B. With a single conspicuous tentacle, others unequally developed or rudimentary.

1. Large tentacle stout and triangular, other three rudimentary; manubrium short and thick . . . . . Euphysa
2. A single large and long tentacle, two very small, and one rudimentary; bell hemispherical and slightly asymmetrical Corymorpha
3. Bell evidently asymmetrical; a single very large tentacle with enlarged base, from which bud proliferously secondary medusæ, other tentacles very rudimentary . . . . . Hybocodon

TIARIDÆ.

A. Marginal tentacles two, opposite.

1. Bell with rather pointed apical projection . . . . . Stomotoca

B. Marginal tentacles numerous.

1. Bell with large, globular, apical process . . . . . Turris
2. Bell without globular apical process . . . . . Turritopsis

MARGELIDÆ.

1. Marginal tentacles eight, symmetrically distributed { Dysmorphosa / Podocoryne }
2. Marginal tentacles eight, rudimentary . . . . . Stylactis
3. Tentacles in eight clusters . . . . . Lizzia
4. Tentacles in four clusters . . . . . Bougainvillia
5. Tentacles in four clusters, each with an erect clavate pair Nemopsis

CLADONEMIDÆ.

A. Radial canals simple.

1. Marginal tentacles two, fringed with stalked nematocysts, bell with subconical apical projection . . . . . Gemmaria
2. Tentacles as in 1, bell hemispherical, without projection Corynitis

B. Radial canals branched.

Marginal tentacles in eight pairs . . . . . Willia

Coryne mirabilis Ag. (FIG. 33).

Bell elongate hemispherical, four to six mm. in diameter; manubrium very long, protruding far beyond the velum, but highly contractile; tentacles likewise very long and filamentous, but capable of great contractility; gonads borne upon body of manubrium and at maturity filling entire bell cavity or even protruding beyond the velum. Fairly common during early spring and summer, swimming near the surface. Hydroid generation, — *Ibid.*

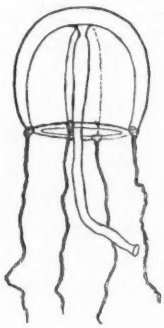

FIG. 33.

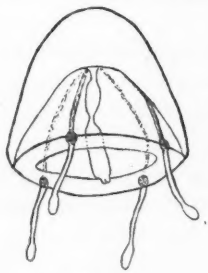

FIG. 34.

FIG. 33. — *Coryne mirabilis* Ag.
FIG. 34. — *Dipurena conica* A. Ag.

Dipurena conica A. Ag. (FIG. 34).

Bell conical or subhemispherical; marginal tentacles four, rather thick and with knob-like ends, and with prominent basal bulbs, each with a single ocellus; manubrium elongate, often extending beyond the velum, the basal portion constricted or narrowed, gastric cavity small, oral opening plain. Size from three to four mm. Common during midsummer. Buzzards Bay, Vineyard Sound, etc.

McCrady (*Proc. Elliott Soc.*, Vol. I) describes from Charleston Harbor two other species of Dipurena, namely, *D. strangulata* and *D. cervicata*, but I find no record of them as occurring elsewhere.

Ectopleura ochracea A. Ag. (FIG. 35).

Bell elongate hemispherical, of nearly uniform thickness, except at the aboral pole, which becomes somewhat conical and correspondingly thicker. In size the medusa varies from four to six mm. Marginal tentacles four,

from the base of which lines of nematocysts extend over the bell to the apex; tentacular bulbs of purplish orange color and each with an ocellus; manubrium rather large and spindle-shaped, of yellowish color.

Hydricthys mirus Fewkes.

Bell oval or subspherical, its outer surface dotted with nematocysts; radial canals four, wide; marginal tentacles four in mature specimens, only two in specimens at liberation; tentacular bulbs reddish in color but without ocelli. The original description was from specimens taken from a colony attached to a fish taken at Newport; other than this I find no records of it. (Cf. *Bull. Mus. Comp. Zoöl.*, Vol. XIII, p. 224.)

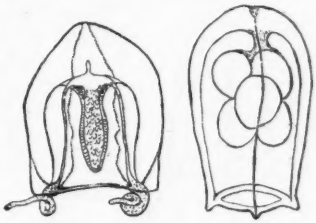

FIG. 35. FIG. 36.

FIG. 35. — *Ectopleura ochracea* A. Ag. (After A. Agassiz.)
FIG. 36. — *Pennaria tiarella* McCr.

Pennaria tiarella McCr. (FIG. 36).

Bell oblong oval, of small size, about two mm. in height and half as broad; radial canals four, narrow, but rather conspicuously marked by lines of pinkish pigment; marginal tentacles very rudimentary from the four tentacular bulbs, which are devoid of ocelli; gonads borne on the walls of the manubrium, and as they approach maturity filling the entire cavity of the bell. The eggs and sperms are discharged promptly upon the medusa becoming free and even before; indeed, in many cases the medusæ are never liberated, as I have elsewhere shown. Color of a general reddish pink or rosy, manubrium a chocolate brown; ova vary in color from pale creamy white to rather bright orange.

Specimens of *P. gibbosa* from Florida and Porto Rico seem to me to be scarcely distinguishable from *P. tiarella*. Hydroid, — Pennaria.

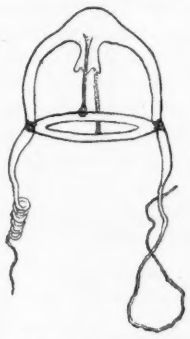

FIG. 37. — *Perigonimus jonesii.*

Perigonimus jonesii Osborn and Hargitt (FIG. 37).

(*American Naturalist*, 1894, p. 27.)

Bell hemispherical, with slight conical apical projection; marginal tentacles two, with four marginal bulbs; tentacles highly retractile and often withdrawn and coiled within the bell cavity when the medusa is irritated. Though these medusæ were kept under observation for several weeks, no gonads were developed.

Habitat: Found upon the legs and abdominal somites of the common crab, Labinia, from which it was repeatedly taken during several seasons. Hydroid, — Perigonimus.

Euphysa virgulata A. Ag.

Bell elongate oval, or quadrangular in outline; tentacles rather heavy and unequally developed, one being much longer and heavier than the others; bases with a pinkish band extending upward along the radial canals for a short distance; manubrium cylindrical with simple oral margins and of yellowish color; gonads upon the sides of manubrium. In size the medusa is from ten to twelve mm. in diameter, of rather active habit and fairly common. Nahant, Massachusetts Bay, and southward.

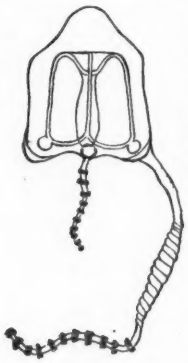

FIG. 38. — *Corymorpha pendula* Ag. (After Agassiz.)

Corymorpha pendula Ag. (FIG. 38).

Bell somewhat unsymmetrical, oblong with subconical apex; tentacles unequally developed, one being quite long and heavy, the others much smaller; manubrium similar to the preceding, both in form and color; bases of tentacles of pinkish color; size from five to six mm. Common along the coast, hydroids dredged from waters of Vineyard Sound, Massachusetts Bay, etc. Hydroid generation, — Corymorpha.

FIG. 39. — *Hybocodon prolifer* Ag.

Hybocodon prolifer Ag. (FIG. 39).

Bell similar to preceding, but with marked asymmetry; a single marginal tentacle of large size, with very thick basal portion, from which there bud proliferously secondary medusæ, which in turn similarly bud tertiary medusæ, several generations in this way being present upon the parent medusa. In other aspects very similar to the preceding. Hydroid generation, — Hybocodon.

Stomotoca apicata Ag. (FIG. 40).

Bell rather open and shallow, with an elongate conical projection at the apex; radial canals four; marginal tentacles two, which are long and slender and highly retractile; manubrium also retractile, with a four-lobed

oral margin. Color: manubrium, yellow or cream-color, base of tentacles purplish. Male often with green manubrium. Hydroid (?).

Stomotoca rugosa Mayer.

General form of the medusa similar to the preceding; apical projection sometimes long, sometimes short and blunt; size about five mm. in height by three mm. broad; two long marginal tentacles and fourteen rudimentary ones; radial canals four; velum well developed. Distinguished from *S. apicata* in part by the distinctively different color, which in this species is of a brick-red at tentacular bases and manubrium, while in the preceding (*S. apicata*) the manubrium is greenish or straw-colored in the male and dull ochre in the female, and the tentacle bases in male are purplish and in female ochre. Hydroid generation, — a Perigonimus.

Habitat: Common at Newport, R. I., and southward.

(Condensed from Mayer's description. *Bull. Mus. Comp. Zoöl.*, Vol. XXXVII, No. 1, p. 4.)

FIG. 40. — *Stomotoca apicata* Ag. (After McCrady.)

Turris vesicaria A. Ag. (FIG. 41).

Bell hemispherical, with large globular projection at its apex; marginal tentacles numerous; bases broad and with a single ocellus on each; tentacles tapering rapidly from the base and becoming delicate and filamentous; manubrium large and with four fimbriated oral lobes; gonads borne upon the base of manubrium and even extending somewhat upon the radial canals, the walls of which are notched and variously irregular, as are also the walls of the marginal canal.

(Condensed from description of A. Agassiz, *No. Am. Acalephæ*, p. 164.)

Hydroid generation, — a Turris (?).

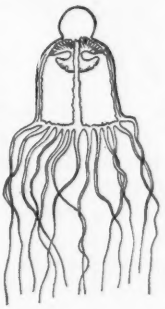

FIG. 41. — *Turris vesicaria* A. Ag. (After A. Agassiz.)

Turritopsis nutricula McCr. (FIG. 42).

Bell high-hemispherical or subspherical; radial canals four; velum broad; marginal tentacles varying from four to thirty or more, depending upon stages of maturity; a reddish ocellus at bases of tentacles; manubrium large but not

FIG. 42. — *Turritopsis nutricula* McCr. (After McCrady.)

reaching beyond the velum; gonads of reddish orange color and arranged in four masses upon the manubrium. Hydroid generation, — a Dendroclava.

Dysmorphosa fulgurans A. Ag. (FIG. 43).

Bell subhemispherical, with slight conical apical projection; radial canals four; marginal tentacles eight, symmetrically disposed; manubrium of medium size, its oral end provided with four rather prominent tentacles; from the body of the manubrium secondary medusæ bud off with great profusion, their numbers at times becoming so great as to afford a splendid phosphorescence (A. Agassiz). Hydroid (?).

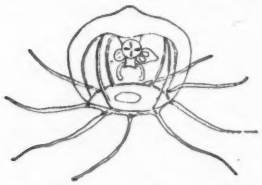

FIG. 43. — *Dysmorphosa fulgurans* A. Ag. (After A. Agassiz.)

Podocoryne carnea Sars (FIG. 44).

Medusa oval or bell-shaped or subglobular, form variable; exumbrella surface dotted with nematocysts; size about five mm. in height by slightly more than half as broad; marginal tentacles eight, four radial, four *interradial*, instead of all *radial*, as stated in Part I in describing the gonosome of Podocoryne, the latter shorter; pinkish ocelli at bases of tentacles; manubrium of medium size, though extensible to velum, of quadrangular form, with four oral lobes tipped with nematocysts; gonads borne on base of manubrium.

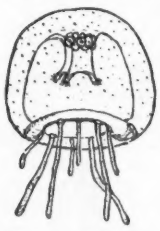

FIG. 44. — *Podocoryne carnea* Sars.

This medusa has been confused with the preceding, which has usually been designated as the product of Podocoryne. This is, however, a mistake. Podocoryne, so far as I am aware, never produces proliferous medusæ from the manubrium, as is the case with Dysmorphosa. I have often followed the direct liberation of the medusæ from the hydroid, and they have even at that time sex products well developed. Bunting has also noted the same thing. (Cf. *Journ. Morph.*, Vol. IX.)

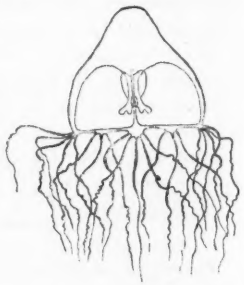

FIG. 45. — *Lizzia grata* A. Ag. (After A. Agassiz.)

Lizzia grata A. Ag. (FIG. 45).

Bell subconical, its apex obtusely rounded; radial canals four; marginal tentacles in eight clusters, the radial groups with five each, the interradial groups with three, in mature specimens; young with only radial tentacles, one at each radius; there are no ocelli;

manubrium of medium size, with four prominent and branched oral tentacles; gonads form prominent masses on body of manubrium. Hydroid (?).

Bougainvillia (*Margelis*) *carolinensis* Ag. (Fig. 46).

Bell subspherical, wall becoming very thick over the aboral part; radial canals four, inconspicuous; marginal tentacles in four clusters, of about ten each; in young specimens just liberated there are but two in each group and the bell is less globular, while the oral tentacles are simple; later these become dichotomously branched about three times; ocelli are grouped about the base of each of the four triangular sensory bulbs. One of the commonest of our Medusæ, reaching at maturity a size of about eight mm. Color greenish or greenish-blue. Hydroid, — *Ibid.*

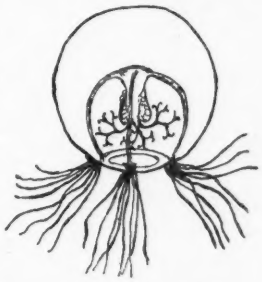

Fig. 46. — *Bougainvillia carolinensis* Ag.

Bougainvillia superciliaris Ag.

In general form and aspect very much like the preceding species, but of larger size and different shape, being somewhat obovate; the marginal tentacles are also more numerous as well as longer, a character common also to the oral tentacles, while the manubrium is broader and shorter. Ocelli as in the former. Of yellowish color. Hydroid, — *Ibid.*

Bougainvillia gibbsii Mayer.

Very similar to the preceding, distinguished according to Mayer by the relatively greater height and smaller width, and by the short and broad manubrium, which in cross-section is cruciform. (Cf. *Bull. Mus. Comp. Zoöl.*, Vol. XXXVII, No. 1, p. 5.) Hydroid (?).

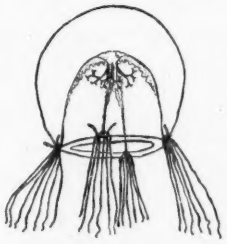

Fig. 47. — *Nemopsis bachei* Ag.

Nemopsis bachei Ag. (Fig. 47).

In general characters Nemopsis has many features in common with Bougainvillia, such as shape, mode of development, etc. The more distinctive differences are to be found in the number and character of the marginal tentacles, more particularly in the pair of erect, clavate ones which spring laterally from the tentacular bulbs, as shown in the figure. Again, the gonads present characteristic differences, arising from the basal portion of the manubrium and extending beneath the radial

canals, in some cases almost the entire length. Ocelli are present and like those in the preceding genus. In color the sensory bulbs are yellowish or orange, as are also the gonads. In size mature specimens vary from six to ten mm. Hydroid (?).

Stylactis hooperii Sigerfoos.

(*American Naturalist*, vol. xxxiii, p. 801.)

Bell globular, slightly elongate, about one mm. in long diameter; radial canals four; marginal tentacles eight, very rudimentary, symmetrically distributed about the margin; ocelli absent; manubrium large, devoid of oral tentacles or lobes; velum narrow; gonads borne in a general mass about the manubrium; genital products discharged at once on liberation of the medusa, which is quite active for a brief time following its liberation, but dies soon after discharge of eggs or sperms.

Habitat: Colony taken from shell of live snail, *Illyanassa obsoleta*. Hydroid, — *Ibid.*

Gemmaria cladophora A. Ag.

Bell hemispherical or subconical, walls rather thick, but varying in different regions, giving to the bell cavity a shape different from that of the external outline; radial canals four; marginal tentacles four, but two rudimentary, the larger abundantly provided with nematocysts, many of which are stalked; tentacular bulbs brownish, with orange pigment at bases; manubrium large, with basal conical portion separated by a sharp constriction from the oral portion, which has a flaring, quadrangular opening. Hydroid (?).

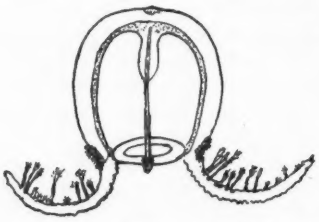

FIG. 48. — *Corynitis agassizii* McCr. (Adapted from McCrady.)

Corynitis agassizii McCr.
(FIG. 48).
(Gemmaria gemmosa McCr.)

Bell elongate-hemispherical or obovate; marginal tentacles two, thick and fringed with an abundance of stalked nematocysts and batteries scattered over the tentacles from base to tip; radial canals four, with clusters of nematocysts at their marginal termini; velum well developed; manubrium of medium size, somewhat conical in shape. Mature specimens from one to two mm. in diameter.

Habitat: Taken from shells of Mytilis, etc. Hydroid, — *Ibid.*

Willia ornata McCr. (Fig. 49).

Body of medusa bell-shaped or conical, with blunt apical projection; marginal tentacles sixteen in mature specimens, arising from the terminals of the branched radial canals; primary canals four in young specimens, which by repeated branching become sixteen, and the development of the tentacles follow the same course of development, appearing after the several divisions of the canals; manubrium rather stout and with lobed oral margins. Intermediate between each pair of tentacles an undulating line of nematocysts, "knotted cords," passes upward on the bell. Hydroid (?).

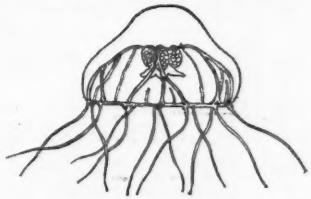

Fig. 49.— *Willia ornata* McCr. (After A. Agassiz.)

(Adapted from McCrady's description, *Proc. Elliott Soc.*, Vol. I, p. 149.)

LEPTOMEDUSÆ.

As compared with the Anthomedusæ, the Leptomedusæ are generally flatter and more disk-like; the velum is usually smaller, and the texture of the bell is softer. Ocelli may or may not be present; otocysts may or may not be present; the gonads are borne upon the radial canals.

SYNOPSIS OF FAMILIES.

I. Thaumantidæ. Ocelli present, but no otocysts; radial canals four or eight (rarely more), always simple and unbranched.

II. Cannotidæ. Without either otocysts or ocelli; radial canals four or six, which are branched or pinnate.

III. Eucopidæ. Otocysts always present, eight or more; ocelli usually absent; radial canals usually four, simple and unbranched.

IV. Æquoridæ. Otocysts always present; radial canals numerous, at least eight, often a hundred or more, usually simple, rarely branched.

Key to Genera.

Thaumantidæ.

A. Radial canals four; marginal tentacles numerous, and with basal cirri . . . . . Lafœa

B. Radial canals eight; marginal tentacles numerous, but without basal cirri . . . . . Melicertum

Cannotidæ.

Radial canals four, each with lateral, sometimes pinnate, branches which end blindly. A single genus within the range of this synopsis so far as known to the writer . . . . . Ptychogena

Eucopidæ.

A. Marginal tentacles four, sometimes with lateral basal cirri.

1. Manubrium very long, extending much beyond velum . Eutima
2. Manubrium short, tentacles with basal cirri . . . . Eucheilota
3. Manubrium short, tentacles devoid of basal cirri . . Clytia (Juv.)

B. Marginal tentacles sixteen or more.

1. Manubrium long, bell hemispherical . . . . . Tima
2. Manubrium short, bell disk-like, otocysts on bases of tentacles Obelia
3. Manubrium short, mouth plain, bell hemispherical, otocysts between bases of tentacles . . . . . Clytia
4. Manubrium short and with fimbriated oral lobes . . . Tiaropsis
   (*a*) With 16 tentacles . . . . . Epenthesis
5. Manubrium short and with oral lobes plain.
   (*b*) With more than 16 tentacles . . . . . Oceania

Æquoridæ.

A. Radial canals eight or more, often lobed or divided at their bases Halopsis

B. Radial canals numerous, twelve to one hundred or more.

1. Manubrium very short, often indistinguishable, and with crenulated oral margin . . . . . Rhegmatodes
2. Manubrium well developed, oral margin lobed but plain Æquorea
3. Manubrium large and with complex and fimbriated oral lobes Zygodactyla

Lafœa calcarata A. Ag. (Fig. 50).

Bell broad, somewhat conical or dome-shaped, marginal tentacles numerous, somewhat swollen at base, long and filamentous, and interspersed with tentacular spurs, clubs, and cirri; gonads suspended in convoluted masses beneath radial canals, of milky or yellowish color; manubrium short and with convoluted oral lobes. When first liberated, the medusa is small and with only two tentacles, others appearing with growth; ocelli are located upon the bases of the tentacles. Size about 20 mm. in diameter. Hydroid, — *Ibid.*

Melicertum campanula Esch.

Medusa bell-shaped or subconical; marginal tentacles very numerous, long, and filamentous, but devoid of basal cirri; radial canals eight at maturity, four in young specimens; gonads suspended in sinuous folds beneath radial canals; manubrium much as in preceding, with oral lobes sinuously convoluted; color of bell light ochre, tentacles and gonads much darker. Reported from Greenland, Grand Manan, Nahant, etc., A. Ag. Newport Harbor, May Mayer. Hydroid (?).

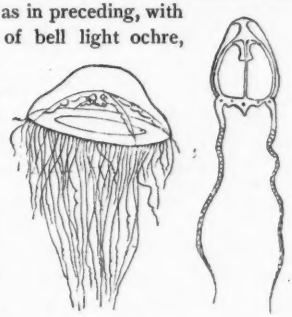

FIG 50.—*Lafœa calcarata* A. Ag. *a*, a young medusa of same. (After A. Agassiz.)

Ptychogena lactea A. Ag.

Bell the small segment of a sphere, walls rather thick; radial canals four, but with sides variously notched and in the medial portions increasing to extended lateral diverticula; tentacles very numerous and filamentous; gonads variously folded and disposed beneath radial canals; devoid of either ocelli or otocysts. According to A. Agassiz (p. 137, *N. A. Acalephæ*), from whose account both this and the preceding description are condensed, this medusa lives chiefly at considerable depths, and exposure to light or increased temperature rapidly disintegrates it. Hydroid (?).

Eutima mira McCr. (FIG. 51).

Medusa broadly bell-shaped, tending to conical; marginal tentacles four, long and tapering from an enlarged base; numerous minute tentacular processes distributed about the margin; otocysts eight, symmetrically disposed; manubrium very long, extending far beyond the velum, and terminating in an everted, somewhat frilled margin; gonads disposed beneath radial canals. Hydroid (?).

FIG. 51.—*Eutima mira* McCr. (After McCrady.)

Eutima limpida A. Ag.

Medusa much as in preceding species, but with both manubrium and tentacles shorter, the latter without the basal swellings of the former and the oral margin less frilled; broad diameter one to two inches, height much less; otocysts large and with numerous lithocysts. Hydroid (?).

Eucheilota ventricularis McCr.

Bell of medusa hemispherical; radial canals four, wide and with the gonads extending their entire length; marginal tentacles twelve to twenty in mature specimens, only four at liberation of medusa; manubrium short, tubular, of yellowish color with reddish central portion; gonads similar in color; otocysts eight, with lithocysts arranged in an arc. Hydroid (?).

Eu. duodecimalis A. Ag. (FIG. 52).

Medusa similar to preceding species, but with twelve otocysts and with only four long tentacles, each with a pair of lateral cirri at the base; gonads borne on distal half of radial canals. Hydroid (?).

Clytia bicophora Ag. (FIG. 53).

Medusa variable in appearance with age; when first liberated, the bell is rather globular, later becoming flattened and finally at maturity being hemispherical; diameter about five mm.; radial canals four, beneath which the gonads, which are dull brown in color, extend from base of the short manubrium about to their middle portion; marginal tentacles eight, with intermediate tentacular buds; otocysts eight. Hydroid, — *Ibid.*

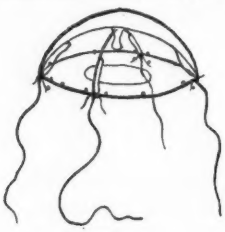

FIG. 52.

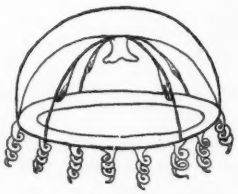

FIG. 53.

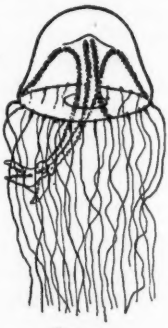

FIG. 54.

FIG. 52. — *Eucheilota duodecimalis* A. Ag. (After A. Agassiz.)
FIG. 53. — *Clytia bicophora* Ag. (After A. Agassiz.)
FIG. 54. — *Tima formosa* Ag. (After A. Agassiz.)

C. nolliformis McCr.

Medusa much as in preceding; marginal tentacles four in young specimens, increasing in number with age; otocysts eight, between bases of tentacles; manubrium short and with four oral lobes. Hydroid (?).

Tima formosa Ag. (FIG. 54).

Medusa bell-shaped or elongate hemispherical; marginal tentacles numerous, long, filamentous, and with bulbous bases; radial canals four, and with convoluted, pouch-like gonads extending their entire length;

otocysts symmetrically distributed about the margin, between the tentacular bases; manubrium large and long, extending beyond the velum, and terminating in a series of fringed, lip-like lobes. Hydroid (?).

Obelia Per. & Les.

Generic characters: Medusa flat and disk-like; marginal tentacles numerous, projecting slightly inward at the base; otocysts eight, borne on base of tentacles at the inner portion; manubrium short and somewhat quadrate. Medusæ often swimming with everted bell.

O. geniculata Linn. (Fig. 55).

Medusa flat; marginal tentacles twenty-four at liberation; gonads as oval bodies beneath middle of radial canals. Hydroid, — *Ibid.*

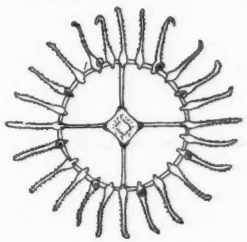

Fig. 55. — *Obelia geniculata* Linn.

O. longissima Pallas.

Very similar to preceding. Hydroid, — *Ibid.*

O. flabellata Hincks.

(Eucope polygena A. Ag.)

In general aspects indistinguishable from the preceding species. Hydroid, — *Ibid.*

O. gelatinosa Pallas.

(Laomedia gigantea A. Ag.)

In general feature similar to former, but with only sixteen tentacles at liberation. Hydroid, — *Ibid.*

O. dichotoma Linn.

Indistinguishable from *O. gelatinosa*. Hydroid, — *Ibid.*

O. commisuralis McCr.

In general features very like the preceding species, but with tentacles somewhat more slender and elongated. Hydroid, — *Ibid.*

Tiaropsis diademata Ag. (Fig. 56).

Medusa ovoid when young, becoming hemispherical at maturity; radial canals four; marginal tentacles very numerous, the larger with swollen bulbous bases; otocysts eight, situated between bases of tentacles and with otoliths in form of arc; gonads extending beneath radial canals; manubrium short, with terminal lobes complexly fimbriated. Hydroid (?).

Oceania languida A. Ag. (FIG. 57).

Medusa ovoid when set free, becoming hemispherical at maturity; radial canals four; marginal tentacles numerous in adult specimens; otocysts eight, situated near bases of tentacles in young specimens, but becoming numerous as medusæ mature, increasing in number according to A. Agassiz by subdivision of the primary otocysts; gonads of brownish or pink or green color, and borne on distal portions of canals. Hydroid (?).

Oceania carolinæ Mayer.

Bell less than a hemisphere, about 14 mm. in diameter; marginal tentacles sixteen, with large hollow basal bulbs, also numerous rudimentary tentacular bulbs interspersed; otocysts 64, symmetrically disposed; manubrium flask-shaped, and with four simple oral lobes; gonads borne on distal portions of radial canals; tentacular bulbs bright yellow-green. Charleston Harbor.

(Condensed from Mayer's description, *Bull. Mus. Comp. Zoöl.*, Vol. XXXVII, No. 1.)

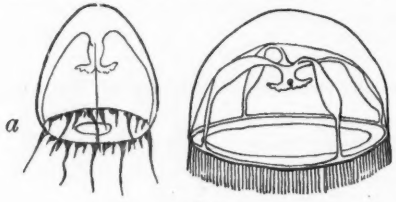

FIG. 56.

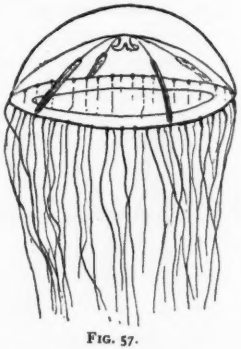

FIG. 57.

FIG. 56. — *Tiaropsis diademata* Ag. (After A. Agassiz.) *a*, young medusa of same.
FIG. 57. — *Oceania languida* A. Ag. (After A. Agassiz.)

O. singularis Mayer.

Bell about two mm. in diameter, with lens-shaped apical projection; marginal tentacles 16, with hollow basal bulbs, and with 16 rudimentary tentacles symmetrically disposed; otocysts 32; gonads borne on upper portion of radial canals; colors of tentacular bulbs and radial canals in region of gonads turquoise-green. Newport Harbor, R. I.

(Condensed from Mayer's description; cf. *op. cit.*)

Epenthesis foleata McCr.

(Oceania foleata Ag.)

Medusa with low, subhemispherical bell, about five mm. in diameter; marginal tentacles sixteen, rather slender and with well-developed basal

bulbs; otocysts alternating with bases of tentacles; manubrium short and with four recurved oral lobes; gonads borne upon lower portions of canals. Manubrium, gonads, and sensory bulbs light greenish in color. Hydroid (?).

Halopsis ocellata A. Ag.

Bell low and flat in mature specimens, though somewhat hemispherical in young medusæ; radial canals twelve to twenty in mature specimens; marginal tentacles very numerous and highly contractile, and with interspersed cirri; otocysts numerous and with numerous otoliths arranged in double rows; manubrium short, with four recurved sinuous oral lobes. Hydroid (?).

(Condensed from description of A. Agassiz, *N. A. Acalephæ*, p. 99.)

H. cruciata A. Ag.

Under this name A. Agassiz briefly describes a medusa having but four radial canals, a hemispherical bell, comparatively few tentacles, and otherwise so unlike the preceding as to render its generic, if not family, affinities wholly distinct. Not having access to specimens, it is merely listed without further comment. Hydroid (?).

Rhegmatodes tenuis A. Ag. (Fig. 58).

Bell low, with rounded aboral surface and with margins distinctly incurved; radial canals numerous, varying from twenty to forty or more in specimens examined; canals usually simple, but with many variations exhibiting connecting branches and anastomoses; marginal tentacles numerous, rather long and filiform, tapering rapidly from a somewhat broad base, above which is a tubular spur-like flap; tentacles, like the radial canals, increase with age, the larger extending from the termini of the canals, while intermediate are smaller ones with still smaller intermediate tentacular rudiments; gonads suspended in double rows along the surface of the canals; manubrium extremely short, often indistinguishable from the very shallow gastric pouch, and with its oral margin delicately crenulated; otocysts numerous.

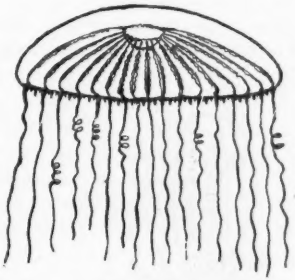

Fig. 58. — *Rhegmatodes tenuis* A. Ag.

In habit these medusæ are rather sluggish, swimming or floating near the surface and rarely exerting more than two or three pulsations of the bell or small velum in succession. Hydroid (?).

R. floridanus Ag.

Very similar to the preceding, though smaller, and of southern range.

Æquorea albida A. Ag.

Bell subhemispherical, tending to conical above; radial canals very numerous, and with two or three marginal tentacles borne between each; otocysts also numerous, spherical, and containing several small otoliths; above the base of each of the larger tentacles is a tentacular spur, similar to those of Rhegmatodes; manubrium short and with simple oral lobes. In size mature specimens vary from one to two inches in diameter. Not uncommon in the vicinity of Buzzards Bay during later summer. Hydroid (?).

Zygodactyla grœnlandica Ag.

This is one of the largest of the Hydromedusæ, sometimes measuring twelve to fifteen inches in diameter; bell rather low and flat; radial canals very numerous; marginal tentacles long and very contractile, and several between the terminals of the radial canals; above the bases of the tentacles are conical spurs quite similar to those of the two preceding genera; manubrium large and elongated, extending beyond the velum when fully expanded, and with densely frilled or fimbriated oral lobes; gonads borne along the lines of the canals as in the former genera. Habitat from Greenland, Maine, Massachusetts, southward. Hydroid (?).

TRACHOMEDUSÆ.

The synoptic characters of this order have already been given. Of representatives there are comparatively few which come within the range of the present synopsis. No details of arrangement under appropriate families will therefore be undertaken in this connection, but the genera and species will be noted so far as known, and some placed provisionally under the order, of whose exact affinities there is doubt. Hydroid generation suppressed.

FIG. 59. — *Trachynema digitale* A. Ag. (After A. Agassiz.)

Trachynema digitale A. Ag. (FIG. 59).

Medusa elongate bell-shaped, the apex rather sharply conical; radial canals eight, rather wide; tentacles numerous and somewhat fragile; otocysts four, rather large, and with colored otoliths; gonads eight, finger-like and suspended from the upper portions of the radial canals. Size of

mature specimens about one inch in long diameter and about half as broad. Reported from Baffins Bay, Massachusetts Bay, Nahant, A. Ag.; Newport Harbor, April, Mayer.

Gonionemus murbachii Mayer. (Fig. 60).

Medusa with low hemispherical bell when in repose, but subconical when in active motion and contraction; radial canals four, prominent and with line of brownish pigment over their course; marginal tentacles numerous, varying from sixteen to eighty or more, rather long but capable of being greatly contracted; rather prominent basal bulbs of brownish color tinged with pale green; a characteristic of the tentacles is the presence of adhesive or suctorial pads a short distance from the tips, beyond which they

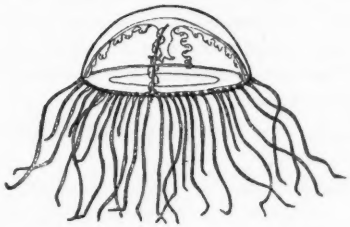

Fig. 60

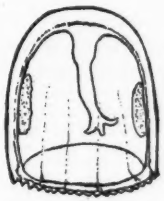

Fig. 61.

Fig. 60. — *Gonionemus murbachii* Mayer.
Fig. 61. — *Persa incolorata* McCr. (Modified from McCrady.)

often are bent at a sharp angle; manubrium of moderate size, quadrate in form and with prominent frilled oral lobes; gonads suspended in sinuous folds beneath the radial canals; otocysts present in variable numbers and disposed between the bases of the tentacles.

Persa incolorata McCr. (Fig. 61).

Bell thimble-shaped, walls thin, the entire medusa colorless except the pale yellowish gonads, which are oval and attached to the walls of two opposite radial canals, of which there are eight, only two of which are very definite; margin of the bell devoid of tentacles, but nodulated by the presence of batteries of nematocysts.

(Condensed from McCrady's account, *Gymn. Charl. Harb.*, p. 104.)

Liriope scutigera McCr.

Described by McCrady (*op. cit.*, p. 106) from Charleston Harbor, and noted by Mayer from Florida (*Bull. Mus. Comp. Zoöl.*, Vol. XXXVII, No. 2, p. 64). Also from Newport Harbor, by latter observer.

NARCOMEDUSÆ.

No representatives of this order have been taken by the present writer along our northeastern coast, and but few have been even reported from within the range of this synopsis. The following records and references may therefore suffice:

Cunoctantha octonaria McCr. Charleston Harbor. *Proc. Elliott Soc.*, Vol. I.

Cunoctantha incisa Mayer. Tortugas. *Bull. Mus. Comp. Zoöl.*, Vol. XXXVII, No. 2, p. 66.

Æginella dissonema Hæck. Tortugas. *Op. cit.*, p. 66.

SIPHONOPHORA.

Of Siphonophora recorded from northeastern Atlantic waters, by far the larger number are products of the Gulf Stream, very few, if any, being indigenous faunal elements. Those more familiar and of commoner record may be grouped under the following sections:

A. DISCONECTÆ. Siphonophora with discoidal pneumatophore, but devoid of nectophores or bracts.

1. *Velella mutica* Bosc. Pneumatophore an elliptical or oblong disk, usually with an oblique vertical crest, and with the several zooids attached to the lower surface. Common in subtropical regions and in Gulf Stream, upon the latter of which they are occasionally borne northward to the New England coast.
2. *Porpita linnæana* Less. Pneumatophore a circular disk, but without a vertical crest. Otherwise similar to former and of similar habits and distribution.

B. CALCYONECTÆ. Siphonophora without pneumatophore, but with one or more nectophores.

1. *Diphyes pusilla* McCr. Polygastric, with two nectophores at the apex of a long tubular trunk.
2. *D. formosa* Fewk. Cf. *Report on Medusæ of Gulf Stream Region.* Commissioner of Fish and Fisheries, 1884, p. 963.
3. *D. bipartita* Costa. Reported by Mayer (*Bull. Mus. Comp. Zoöl.*, Vol. XXXVII, p. 74) from Newport, R. I.
4. *Agalmopsis carum* A. Ag.
   Nanomia cara A. Ag. Polygastric, with long tubular trunk and with numerous siphons and bracts.
5. *Agalma okenii* Esch.
6. *Spheronectes gracilis* Haeck. Reported by Fewkes from Newport, R. I. (*Bull. Mus. Comp. Zoöl.*, Vol. VIII, p. 166.)
7. *Gleba hyppopus* Forsk. Reported by Fewkes off Marthas Vineyard. (*Rept. U. S. Comm. Fish and Fisheries*, 1884, p. 963.)

C. CYSTONECTÆ. With large vesicular pneumatophore only, no nectophores or bracts.

Physalia pelagica Bosc. Common along the coast, occasionally taken at the Bay of Fundy. The well-known Portuguese-man-of-war. One of the most conspicuous of the siphonophores, and with long graceful tentacles which are loaded with batteries of nematocysts of highly venomous character.

In the foregoing synopsis only incidental notice has been made of synonomy, any details on this line being incompatible with the purpose and limits of the paper.

It is a pleasure to acknowledge in this connection my obligations to Dr. Alfred G. Mayer, of the Brooklyn Institute, who has kindly reviewed the manuscript of Part III of this synopsis, and offered suggestions, and from whose various recent papers on Medusæ I have been able to extend the list of species in several cases.

I desire also to acknowledge the services of my son George, who has copied most of the figures and has under my direction drawn most of those made directly from nature.

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CONTRIBUTIONS FROM THE ZOÖLOGICAL
LABORATORY OF SYRACUSE UNIVERSITY, February, 1901.

REVIEWS OF RECENT LITERATURE.

ZOÖLOGY.

An Anatomy of the Cat. — From the standpoint of teaching anatomy to the beginner, few animals have received more attention than the cat, and the number of easily accessible books dealing with the structure of this animal is already large. The preparation of a new volume as a competitor in this field is hazardous, to say the least, and the present venture seems all the more so because its authors, Reighard and Jennings,[1] do not propose to treat the subject in any novel way, but content themselves with the simple descriptive methods of the older anatomists.

The text embodies a well-arranged systematic description of the organs of the cat. The terminology is for the most part a judicious compromise between the various recent attempts at a revised nomenclature and the older systems. Its innovations are based chiefly on greater convenience in the use of terms, a principle which, though often ignored, eventually makes itself felt in the growth of all nomenclatures. The orthography is said to follow the best English usage, in which case there should have been no final *e* in "foramen of Monroe."

The anatomical descriptions impress the reader as having been taken directly from the specimen, and, as a rule, show none of the forced character that is so often seen in Mivart's account, where at times human anatomy seems to be directly transferred to the cat. The description of the divisions of the body cavity, however, is distinctly misleading. The reader is told that this cavity is divided by the diaphragm into two parts, an abdominal cavity and a thoracic cavity, and the latter is described in some detail. The thorax of a cat, however, does not contain a single large cavity but three such, one for the heart and one for each lung, and it is only after the scalpel of the student has been at work some time that such a cavity as that described can be said to exist. The impropriety of including such openings in the description of the anatomy of an animal must

[1] Reighard, J., and Jennings, H. S. *Anatomy of the Cat.* Henry Holt & Co., 1901. xx + 498 pp., 173 figures.

be obvious, and its only excuse is the bad example set by human anatomists in this respect. Not only are the cavities of the thorax thus unnaturally united, but the abdominal cavity, really one, narrowly escapes being divided in two, a condition which the authors, however, finally imply to be contrary to fact.

The text is illustrated by one hundred and seventy-three original figures, many of which, particularly the drawings of muscles, are models of clearness and accuracy. Some, however, especially those on the brain, lack firmness, and a few, such as Fig. 42, are so shaded that more or less of the lettering can be discovered only by elimination.

The descriptive portion of the work is followed by some forty pages of practical directions which give all that is needed for so simple a subject as the dissection of the cat, and the volume is concluded by an index of nearly three thousand entries.

Although the book is in a well-worked field, it certainly occupies a unique position, for none of its predecessors can be described as accurate, complete, and compact. These qualities will without doubt place it first among English guides to the anatomy of the cat.

P.

Two Recent Papers on the Lampreys. — In the *Fourth Annual Report of the Commissioners of Fisheries, Game, and Forests*, of New York, Professor H. A. Surface of Pennsylvania State College has a very interesting study of the lampreys of New York from the economic standpoint. He shows that the lampreys rank first in the rivers of New York as enemies of other fishes, yet not one word had hitherto been written as to any method of reducing their numbers.

Professor Surface gives a detailed account of the four lampreys found in New York, their habits, their enemies, and the species of fish on which they attach themselves, rasping off the flesh until the fish dies. The spawning habits are treated with especial care, and the fact that all die after once spawning is apparently well established.

Experiments with weirs of wire and with hand nets show what large numbers of lampreys could be destroyed in the spawning season with little expense. In the interest of other fishes, this should be done in streams and lakes which lampreys infest.

Professor Surface's paper is illustrated by numerous photographs of scenery, and of the spawning lampreys, as also of the catfishes and other fishes destroyed by them. As a practical study in economic zoölogy, this work is to be highly commended.

In the *Journal of the College of Science*, in the Imperial University of Tokyo, Dr. S. Hatta of the College of Peers has an important memoir on the development of "Pronephros and Segmental Duct in the Lamprey." It is a worthy member of the series of admirable papers setting forth the original investigations of the students and associates of Professors Mitsukuri, Watase, and Iijima — one of the most hopeful phases of the development of New Japan.

D. S. J.

Notes. — The anatomy of the wings of the thrushes belonging to the genus Micropus has been very fully worked out by Buri (*Jena Zeitschr.*, Bd. XXXIII, pp. 361–610). The account includes a full description of the brachial plexus and of the muscles of the wing, and is based on a broad comparative study of the subject. Unfortunately the general results are meagre and pertain chiefly to minor questions in the taxonomy of this group of birds. As an illustrated record of the comparative anatomy of the parts investigated, Buri's contribution is a praiseworthy effort.

The number of ants in a hill has been variously estimated. Forel made an indirect calculation for a hill of medium size of *Formica pratensis* and arrived at the conclusion that it contained 114,000 ants. The largest hills he thought might contain as many as 500,000. In these conclusions he was supported by Lubbock. Yung (*Archives Zoöl. Expérim. et Générale*, 3 Sér, Tome VII, pp. xxxiii–xxxv, 1900), however, has made actual counts of all the inhabitants in several isolated hills of *Formica rufa*. He has found the numbers to vary between 19,933 and 93,694 and not to be proportional to the size of the hill. He believes that the previous estimates have been exaggerated.

The New York State Entomological Field Station, which held its first session at Saranac Inn last summer, will remove to Ithaca for the coming season. Professor James G. Needham of Lake Forest University will continue in charge of the work. The report of the first session, which is expected to issue shortly, will contain among other things extensive contributions to the knowledge of the life histories of aquatic insects, especially dragon flies, may flies, and caddis flies, and a few very interesting forms of Neuroptera and Diptera.

Although the medullary substance of the brains of most vertebrates has been rather fully studied, this portion of the ungulate brain, for some unknown reason, has received very little attention.

To remedy this defect Schellenberg (*Jena. Zeitschr.*, Bd. XXXIV, p. 113) has made an extended study of the medullary parts of the brains of goats, sheep, oxen, horses, and swine. In all these the centrum ovale is relatively small. The excessive size of the fibrous masses in the frontal lobes of swine is attributed to the well-developed sense of smell in these animals. In a similar way the great masses of medullary substance in the occipital lobes of the goat are supposed to be associated with the well-known quickness of sight of this animal. The fornix was about equally developed in all the ungulates studied, but the corpus callosum was relatively most prominent in the goat. As this organ is suspected of being connected with the associative operations of the cortex, its great size in the goat may be an indication of the rather remarkable psychical qualities of this animal as contrasted with sheep, etc.

BOTANY.

The Phytogeography of Nebraska[1] appears in a new and revised edition, in the preface to which the authors state that the greater portion of the first edition was destroyed in a fire that consumed the publisher's buildings. We cannot but rejoice in the calamity, for we ever felt that the form in which the work was cast was an injustice to its exceeding high merit and true worth. We cannot, however, but regret that the opportunity was not taken advantage of to carry the revision still farther. In our opinion it would have been better to have entirely reëdified the structure on a new foundation. The very excellent material was deserving of this. Rapid as has been the evolution of the two volumes, — witness the timely insertion relative to frequence and abundance, so conspicuously absent from the first edition ; the better treatment of the important factor of light, — these but examples of numerous improvements, — yet we cannot but feel that the present method of treating the habitat group is the pernicious root of much evil that afflicts our ecological classification. The habitat group should be relegated to an inferior position, or better abolished altogether, than as at present producing turgidity in what would by a more logical treatment be perfectly clear. Without

[1] Pound, Roscoe, and Clements, F. E. *The Phytogeography of Nebraska.* I. General Survey. Published by the Botanical Seminar of the University of Nebraska. Lincoln, 1900. Second edition. 422 pp., with four maps.

doubt, when the terminology and classification shall have become settled into a more consistent form, a more lucid, logical, and workable method will result. Future authors of similar treatises are hardly likely to adopt our authors' treatment of biological and ecological relations, grouping all but the larger families under cohorts. Would it not be better to incorporate much of this information in the description of formations, and the remainder under ordinal and specific caption in the descriptive lists of Nebraskan plants issued in other volumes, and to which this work is in a manner the introduction?

Whatever of deficiency the work possesses, however, is entirely of form. The work itself is of such high merit that it will bear any amount of criticism, and the indication of its defects will but bring into prominence its great excellence. The energy and enthusiasm of its authors are everywhere evident; but, having to find their own path, since the European masters of this new department of science could but indicate the direction, they have had, with often inept term, to translate or invent new phrases to fit the new conditions here presented. Again they have been at some disadvantage in their field of operations, since but few states of the Union offer less topographic diversity than Nebraska. With scarcely any rock exposure whatever, it was not a propitious field in which to study the chemical composition of soils and the consequent result on vegetation, particularly in its opposite phases as illustrated in semi-mountainous regions where on calcareous and siliceous substrata interesting and hitherto little analyzed or described conditions prevail. The groups of plants below the Pteridophyta seem to play but a very insignificant part in Nebraska, and students elsewhere will find in these lower groups much more that is noteworthy, and the increased attention constantly being paid to the lower cryptogams will cause a fuller treatment to be thoroughly appreciated.

The work, however, as it stands cannot be too highly commended and recommended to botanical students and workers, to many of whom indeed it is indispensable. Teachers and others may fitly use it as supplementary to a study of plant physiology, of which it is a concrete example. Apart from its high value as displaying the floral covering of a large territory, purely as a work on phytogeography and ecology it is at present by far the best American work we have. It is an example of what may be done under efficient leadership and with proper enthusiasm. Great credit is due to the authors and their colleagues. It has required a vast amount of labor to collate

such a mass of useful and thoroughly reliable information, and when we consider the painstaking care and discrimination with which it has been done, we cannot sufficiently thank the authors, Professor Bessey, to whom the inception of the work was due, and the several workers who are given credit in the preface. Their work is undoubtedly destined to exert a far-reaching influence and act as a stimulus everywhere. Is it too much to hope that before long every state and even much lesser divisions may be as well explored botanically as Nebraska?

COLTON RUSSELL.

The Cyclopedia of American Horticulture.[1] — The third volume of this important work, the earlier volumes of which were noticed in the *Naturalist* for April and September, 1900, sustains the high character with which the Cyclopedia began, — as, indeed, was to be expected, since the work as a whole was planned and the preparation of the later volumes well in hand before the appearance of the first volume. Leaving a fuller notice of the entire work until the concluding volume shall have been received, which will scarcely be later than autumn, it may be said now that among the subjects of special interest in the present volume are the revisions of Narcissus, Nymphæa, Pæonia, Papaver, and Pelargonium, representatives of which are commonly cultivated in our flower gardens in the open air; Nepenthes, Odontoglossum, Oncidium, Oxalis, and Primula, treated as house plants; the genera Opuntia, Picea, Pinus, Populus, Prunus, Pyrus, and Quercus, of botanical interest; the Orange, Peach, Pear, and Plum, of further interest to the fruit-grower; Orchids and Palms, of comprehensive gardening contents; and instructive articles on the physiology of plants, and plant breeding.

T.

The Flora of Cheshire. — J. Byrne Leicester Warren, Lord de Tabley, a man little heard of in this country as a botanist, but one of the most painstaking followers of one branch of that science, of the passing generation, affords a good illustration of the versatility of the English gentleman, for he was at once a poet of no mean attainments, an authority on numismatics, a conservative politician, and a man one of whose principal pleasures through life was direct and interested contact with nature. A quarter of a century ago he

[1] Bailey, L. H., and Miller, W. *Cyclopedia of American Horticulture, N–Q.* New York, The Macmillan Company, 1901. xv + 432 pp., 11 pls., 606 figs.

had prepared a manuscript flora of the county of Cheshire, but did not publish it. At the time of his death, in 1895, a new manuscript, except for a few late gamopetalous orders, had been fairly completed, and because of the wish of his sister, Lady Leighton, this was edited and revised by Spencer Moore and published a little over a year since.[1]

Few local floras are prefaced by poetry, original or copied, and one is given to looking askance at a scientific work in any part of which rhyme is encountered; and yet *The Flora of Cheshire* of De Tabley is really excellent, applying Watson's principles of distribution in a careful census of the plant growth of an interesting district, the real value of which is emphasized by the simple statement of his editor that in compiling the orders omitted from his later manuscript, though the earlier manuscript and certain memoranda found among the author's papers were used, this portion of the work is perforce left imperfect.

If with the present writer any others who handle the book desire a little deeper glimpse into the life of its author, they will find a further sketch of his life in the *Journal of Botany* for February, 1896.

T.

Notes. — The *Proceedings of the Society for the Promotion of Agricultural Science* for 1900 contains the following botanical papers: Beal, Syllabus for a short course on grasses and other forage plants; Munson, The development of a tomato hybrid; Tracy, Individual prepotency in plants of the same breeding; Chester, The chemical functions of certain soil bacteria; Galloway, Twenty years' progress in plant pathology; Trelease, The botanic garden as an aid to agriculture; Halsted, Seven years of experiments with bush beans; Rowlee, The value of willows in retaining the banks of streams; Bolley, The course of the hyphal filaments of Tilletia in the body of the wheat plant; Pammel, The course in cryptogamic botany; Pammel, The weedy plants of Iowa.

In the *Botanical Magazine* of Tōkyō, for January 20, Mr. Hemsley publishes a new genus of Bixineæ, under the name Itoa, given it in honor of Dr. Keisuké Ito, the Nestor of Japanese botanists, who recently died at the advanced age of ninety-nine, and his grandson, Dr. Tokutaro Ito, also a well-known botanist; and a figure of the type

[1] Tabley, Warren de. *The Flora of Cheshire.* Edited by Spencer Moore, with a biographical notice of the author by Sir Mountstuart Grant Duff. London, Longmans, Green & Co., 1899. cxiv + 399 pp., portrait and map.

species, *Itoa Orientalis* is published in *Hooker's Icones Plantarum* for February.

A series of lithographic illustrations of Cactaceæ, under the direction of Dr. Schumann, is appearing from the press of J. Neumann of Neudamm, under the title *Blühende Kakteen.* The two fascicles thus far issued contain rather indifferently colored habit sketches of flowering plants, which could be made far more valuable by the addition of detail analysis of pulvini and floral structure.

Mr. Bicknell writes on the nomenclature of Agrimonia in New England, in the *Bulletin* of the Torrey Botanical Club for February, which further contains notes on the insular flora of Mississippi and Louisiana by Lloyd and Tracy, The home of *Botrychium pumicola* by Coville, North-American Plantaginaceæ by Morris, and a revision of the North-American species of Heterocladium by Best. Dune plant communities are well shown in the plates accompanying the article by Professors Lloyd and Tracy.

Further descriptions of East-American species of Cratægus, by W. W. Ashe, are separately printed from the *Journal of The Elisha Mitchell Scientific Society*, under date of December 20.

Cotyledon purpusii, of California, is figured on plate 7713 of *Curtis's Botanical Magazine.*

A paper on the sunflower, *Helianthus annuus*, by Professor Wiley, constitutes *Bulletin 60* of the Division of Chemistry of the United States Department of Agriculture.

Forms and hybrids of several species of Chenopodium are discussed by Dr. J. Murr, in recent numbers of the *Oesterreichische Botanische Zeitschrift* and *Deutsche Botanische Zeitschrift.*

Anatomical studies of *Chamærops humilis*, *Phœnix dactylifera*, and their supposed hybrids for which Naudin proposed the generic name Microphœnix, by Bargagli Petrucci, published in Vol. XIV of *Malpighia*, are held to demonstrate that the two supposed species of Microphœnix are not true hybrids, but merely forms of *Chamærops humilis.*

No. 15 of Holm's "Studies in the Cyperaceæ," in *The American Journal of Science* for March, deals with some species of Carex of the group Astrostachyæ.

The plumose *Asplenium ebeneum Hortonæ* is the subject of a note by its discoverer, in *The Plant World* for February.

A list of Alabama species of Cercospora, by Professor Carver, is published as *Bulletin No. 4* of the Experiment Station of the Tuskegee Normal and Industrial Institute.

Diseases of Antirrhinum, caused by *Colletotrichum Antirrihini* and an undetermined Phoma, are described by Stewart in *Bulletin No. 179* of the New York Agricultural Experiment Station.

A committee of the Vermont Botanical Club, with President Ezra Brainerd as chairman, has recently published a list of the spontaneous spermatophytes and pteridophytes of that state, as an extract from the *Twentieth Vermont Agricultural Report.*

A preliminary list of the flowering plants of North Dakota, by Bolley and Waldron, is published as *Bulletin No. 46* of the Experiment Station of that state.

Under the title "Collectanea ad floram Argentinam," Dr. Kurtz has reprinted from Vol. XVI of the *Boletin de la Academia de Córdoba* a series of critical notes on Argentine plants, a number of which occur also in the United States.

A first part, historical and bibliographic, of a Flora Romana, by Pirotta and Chiovenda, constitutes the opening fascicle of Vol. X of the *Annuario del R. Istituto Botanico di Roma.*

Die Flora der deutschen Schutzgebiete in der Südsee, by Schumann and Lauterbach, is a thick quarto volume, with a map and 23 plates, just issued from the Borntraeger press of Leipzig, and furnishes another evidence of the scientific activity of the Germans abroad as well as at home.

A seventh part of Koorders and Valeton's "Additamenta ad cognitionem floræ arboreæ Javanicæ," covering the orders Araliaceæ to Verbenaceæ, forms No. 42 of the *Mededeelingen uit s' Lands Plantentuin.*

The latest nomenclature development is an appeal "an den Landtag des Königreichs Preussen," for the suppression of Engler's *Das Pflanzenreich* as a menace to science. Needless to add that Dr. Otto Kuntze is the plaintiff in the case.

Continued American interest in nomenclature reforms and upheavals is shown by an incisive article by Mr. Fernald in *The Botanical Gazette* for March.

Dr. Cowles's "Physiographic Ecology of Chicago and Vicinity," in recent numbers of *The Botanical Gazette*, is an interesting presentation

of an interesting subject, and, like his earlier work, is illustrated by process reproductions of well-chosen photographs.

An ingenious door device for herbarium cases is described and figured in the report of the Director of the Field Columbian Museum of 1899–1900, recently issued as *Publication 52* of that institution.

The vexed question of the preservation of herbarium specimens by impregnation with poisons is rediscussed by Paiche in No. 3 of the current volume of the *Bulletin de l'Herbier Boissier.*

A biographic sketch of J. G. Agardh, by Magnus, is published in the *Naturwissenschaftliche Rundschau* for February 28.

A biographic sketch, with portrait, of the late Thomas A. Williams appears in *The Asa Gray Bulletin* for January, a journal of which Professor Williams was editor-in-chief at the time of his death.

Portraits of Thomas Meehan and Frederick Law Olmsted are published in *The American Florist* of March 23.

PALEOBOTANY.

The Jurassic Flora of Great Britain.[1]—The present contribution from the pen of Mr. Seward, which will find a warm welcome from paleobotanists generally, deals with the fossil plants from the Inferior Oölite of the Yorkshire coast and is presented in the form of an illustrated catalogue, which is evidently designed to serve as the basis of further systematic treatment of the species, as well as of a more ample discussion of stratigraphical relations. In the present volume, therefore, the author attempts little beyond an endeavor to record the location of the various types found; to discuss the different species historically; to illustrate each type by excellent drawings; to institute a preliminary comparison with the Jurassic floras of other countries, and to simplify the nomenclature. Generic and specific diagnoses are presented only in special cases.

The material utilized is primarily that contained in the British Museum and represented by six different collections, of which the specimens derived from the collection of the late William Bean of Scarborough, by purchase in 1859, constitute the most important elements. Another section of the Bean collection is deposited in

[1] Seward, A. C. A Catalogue of the Mesozoic Plants in the Department of Geology, British Museum, Part III. The Jurassic Flora. London, 1900. Large 8vo. 341 pp., 21 plates.

the Museum of the Yorkshire Philosophical Society at York. The study of the material contained in these two museums has been supplemented by an examination of specimens in the Museums of Cambridge, Whitby, Scarborough, Oxford, Manchester, Newcastle, and Leeds, all of which are rich in collections of Yorkshire coast plants, and also of specimens in the collections at Paris, Lund, Stockholm, and other continental museums.

The author's experience shows that the identification of type specimens which have become so widely distributed is a very difficult and often fruitless task, and his appeal for some definite system whereby such important material may be centralized and the types thereby preserved and made accessible, is one which must meet with strong sympathy from paleobotanists elsewhere.

The Cliff sections of Jurassic plant-bearing strata exposed along the Yorkshire coast from Whitby to a few miles south of Scarborough have afforded unusually rich data bearing upon our knowledge of Mesozoic vegetation, and Mr. Seward points out that the flora of this particular district is the richest among Mesozoic floras from British localities, both as regards the number of species and the abundance of material, and that it is scarcely surpassed by any assemblage of fossil plants from extra-British regions. The large amount of this material which has found its way into various European collections has resulted at various times in partial descriptions by Brongniart, Sternberg, and other continental paleobotanists. As long ago as 1828, Brongniart described twenty-two species of these plants, and during the period from 1831–37, Lindley and Hutton published forty-seven species. In 1874 Professor Phillips recorded ninety-five species in the last edition of his work. At different times various other authors have published minor lists, but the most important contribution from a numerical point of view was that of Fox-Strangways and Barrows, who recorded one hundred and seven species in Vol. II (Yorkshire) of the *Geological Survey Memoirs*. But up to the present date no systematic attempt has been made to deal with the flora exhaustively and ascertain its geographical distribution ; to compare it with older and younger floras, as also with recent species ; to determine the conditions under which the plants grew, and to recognize the most characteristic species with a view to their employment as indices of geological age. This task has now been assumed by Mr. Seward after the lapse of forty-two years, and in the catalogue before us we are presented with the initial results of his studies.

An examination of extra-British Jurassic plants presents in convenient form an approximate comparison of the Jurassic floras of the various countries of the world, and the probable identity of such species with, or their resemblance to, British types is made clear by the use of a tabular presentation.

The present studies offered some conclusions of interest, of which the following may be noted:

The Jurassic flora shows a great preponderance of ferns and cycads, with relatively few conifers, and a remarkable paucity of the Equisetales and Bryophyta, in all of which features it exhibits a striking similarity to the flora of the Wealden as described in previous British museum catalogues, while they appear to be directly connected by a few apparently identical species, such as *Matonidium gœpperti*, *Ruffordia gœpperti*, and *Ginkgo digitata*, which are common to both floras.

Among the Equisetales the generally large size of the stems indicates a much nearer approach to the arborescent forms of the Triassic and Palæozoic than to the diminutive representatives found among the modern horsetails. In *Equisetites columnaris*, which is one of the most common and characteristic plants of the Yorkshire flora, the author finds evidence that the small seams of coal which occur in strata of the Estuarine series, were formed in part, if not entirely, from the remains of the Equisetaceous plants which flourished in the Jurassic swamps.

Ferns of the Sagenopteris and Cladophlebis types, while often abundant, afford little satisfactory evidence of relationship, which is much more clearly indicated by the Matonineæ and Dipteridinæ, which were abundantly represented in Jurassic time, and also by the Osmundaceæ and Cyatheaceæ. The Schizeaceæ were also represented by a few doubtful examples, but the Gleicheniaceæ and the Marattiaceæ are as yet unknown elements in the Yorkshire coast flora. From the types so far recognized it appears that this flora finds its closest resemblances among existing species in the Southern Hemisphere, where the Malayan *Matonia pectinata*, the Asiatic *Dipteris*, *Dicksonia arborescens* of St. Helena, and *Todea barbara* of New Zealand and Australia offer the closest parallelisms.

Among the Ginkgoales, both Ginkgo and Baiera are characteristic of the Jurassic floras, and they appear to have extended back through the Triassic into the Permian. Their extreme northern range points with considerable force to a vigorous development of the Ginkgoales during later Mesozoic time.

The Jurassic in Great Britain, as in North America, was essentially the Age of the Cycads, a fact strongly emphasized by the Yorkshire flora where Williamsonia, Otozomites, and Nilssonia formed conspicuous elements.

As already pointed out, the Coniferæ are much less abundant in this flora than either the ferns or the cycads, but the evidence so far obtained makes it impossible to determine how far this is to be accepted as an expression of their actual relation to the original flora, since local conditions may have operated to exclude a large proportion of such plants from preservation as fossils. The nearest existing types appear to be represented chiefly by various species of Araucaria, although Podocarpus is also suggested by *Nageiopsis anglica*. The Abietineæ, which assume an important position in the Wealden and Lower Cretaceous floras, have no well-defined representatives in the Yorkshire flora.

So far as any general conclusions are justifiable upon the basis of the present studies, it would seem probable that in seeking comparisons between the Jurassic flora of the Yorkshire coast and the vegetation of the present time, we must turn to the southern tropics. In the general character of the vegetation, therefore, as also in the luxuriant growth of Equisetums and ferns, we observe evidence not only of a moist climate, but also indications that the climate of England during Jurassic time must have been considerably more tropical than at present.

D. P. PENHALLOW.

QUARTERLY RECORD OF GIFTS, APPOINTMENTS, RETIREMENTS, AND DEATHS.

EDUCATIONAL GIFTS.

Albion College, Michigan, $10,000, for a library building, from Mrs. C. T. Gassette.

Alleghany College, Pennsylvania, a conditional gift of $60,000.

American Museum of Natural History, New York, $1500, from John L. Cadwalader, for mounting birds.

Armour Institute, $1,000,000, from Mrs. P. D. Armour and J. Ogden Armour.

Barnard College, $5000, from Jefferson Seligmann.

Baylor University (Texas), $60,000, from George W. Carrol, for a science building.

Bethany College, $240,000, by the will of the late R. S. Walton of Philadelphia.

Brown University, $150,000, for a library building; $500,000, for its endowment, and the unrivaled John Carter Brown Library of Americana, from John Nicholas Brown.

Columbia University, $10,000, by the will of Benjamin D. Silliman.

Cornell University, $10,000, from Mrs. Roswell P. Flower, for the library of the Veterinary College.

Creighton University (Omaha), $75,000, from John A. Creighton.

Cumberland, Maryland, Public Library, a conditional gift of $25,000, from Andrew Carnegie.

Dartmouth College, $100,000, from Edward Tuck, for a building for the school of administration and finance; $10,000, by the will of Mrs. Susan A. Brown, for the philosophical library.

Des Moines College, Iowa, a conditional gift of $15,000, from John D. Rockefeller.

Galesburg, Illinois, Public Library, a conditional gift of $50,000, from Andrew Carnegie.

Harvard University, $5000, by the will of Jacob Wendell, for a scholarship.

Lafayette, Indiana, $15,000, from Mrs. Robert H. Hitt and Mrs. L. Diaz Abertini, for public library purposes.

Lewiston, Maine, a conditional gift of $50,000, for a public library, from Andrew Carnegie.

Marion, Indiana, Public Library, a conditional gift of $50,000, from Andrew Carnegie.

Mercer College, Georgia, a conditional gift of $15,000, from John D. Rockefeller.

Mt. Vernon, N. Y., Public Library, a conditional gift of $35,000, from Andrew Carnegie.

New York City, $5,200,000, for branch public libraries, from Andrew Carnegie.

Oberlin College, $150,000, from various sources, being half of the sum necessary to secure the conditional gift of $200,000 from John D. Rockefeller.

Phillips Academy (Andover), $150,000, from an anonymous donor, for a department of archæology.

Port Jervis, N. Y., Public Library, a conditional gift of $20,000, from Andrew Carnegie.

Princeton University, $100,000, from Henry S. Little, for a new dormitory.

Richmond College, Virginia, a conditional gift of $75,000, from John D. Rockefeller.

St. Louis, $1,000,000, from Andrew Carnegie, for a public library.

Schenectady Public Library, a conditional gift of $50,000, from Andrew Carnegie.

Teachers' College, New York, $100,000, from an anonymous giver.

Tulane University, about $2,000,000, by the will of Mrs. Josephine L. Newcomb, for the Sophie Newcomb College for Women.

University of California, $24,000, from Mr. D. O. Mills, of New York, for an astronomical expedition.

University of Minnesota, $50,000, from John B. Gilfillan.

University of Pennsylvania, $200,000, from Randolf Morgan, for a physical laboratory.

University of Southern California, a conditional gift of $25,000, from Mrs. Anna C. Hough.

Watertown, N. Y., $60,000, from Mrs. Emma Flower Taylor, for a public library.

Wellesley College, $25,000, from H. H. Hunnewell, for the botanical department; $15,000, by the will of Miss Mary Shannon.

Western Reserve University, $12,000, from H. M. Hanna.

Yale University, $110,000, by the will of Benjamin D. Silliman; $100,000, from an anonymous donor, for a medical school building; $6000, from the family of the late Robert Callender, for a scholarship; $10,000, from Jonathan Bulkley, for a fellowship; $50,000, by the will of George T. Bliss; $25,000, from William C. Whitney; $10,000, from Mrs. S. H. Camp, for the library of the philosophical department.

APPOINTMENTS.

Alexis P. Anderson, curator of the herbarium of Columbia University. — S. M. Bain, professor of botany in the University of Tennessee. — Dr. Joshua W. Beede, instructor in geology in the University of Indiana. — Dr. Robert Bell, director of the geological survey of Canada. — Dr. W.

Benecke, docent for botany in the university at Kiel, titular professor. — Dr. H. Borultan, docent for physiology in the university at Göttingen, titular professor. — John A. Bownocker, professor of inorganic geology in the Ohio State University. — Dr. Brauer, docent for geology and paleontology in the Munich Technical School. — Dr. August Brauer, docent for zoölogy in the university at Marburg, titular professor. — Dr. Hermann Braus, of Würzburg, professor extraordinary of anatomy in the University of Heidelberg. — E. J. Butler, official botanist to the Indian government. — Dr. Alexander F. Chamberlain, acting assistant professor of anthropology in Clark University. — Henry E. Crampton, adjunct professor of zoölogy in Barnard College. — Samuel M. Coulter, instructor in botany in Washington University. — Dr. August Denckmann, geologist in the Berlin geological Anstalt. — Dr. Karl Escherich, docent for zoölogy in the university at Strassburg. — Dr. Richard Ewald, professor of physiology and director of the physiological institute in the university at Strassburg. — A. W. Evans, assistant professor of botany in Yale University. — Miss Margaret C. Ferguson, instructor in botany in Wellesley College. — George I. Finlay, assistant in geology in Columbia University. — E. J. Garwood, professor of geology and mineralogy in University College, London. — Georg Geyer, chief geologist of the Austrian Geological Survey. — Dr. Ernst Gilg, curator of the botanical museum of the University of Berlin. — H. E. Gregory, assistant professor of physical geography in Yale University. — W. Gunn, district geologist of the British Geological Survey. — Dr. A. C. Haddon of Dublin, Junior Fellow in Christ's College, Cambridge. — Dr. Hauptfleisch of Würzburg, assistant in botany in the Stuttgart Technical School. A. S. Hitchcock of Kansas, assistant agrostologist in the U. S. Department of Agriculture. — John Horne, assistant director (for Scotland) of the British Geological Survey. — Dr. H. S. Jennings, assistant professor of zoölogy in the University of Michigan. — Dr. W. Karawaieff, director of the zoölogical station at Sebastopol. — Dr. K. Keilhack, professor of geology in the Berlin Mining School. — W. E. Kellicott, assistant in zoölogy in Barnard College. — Dr. F. Kossmat, adjunct of the Austrian Geological Survey. — G. W. Lamplugh, district geologist of the British Geological Survey. — Dr. C. F. W. McClure, professor of comparative anatomy in Princeton University. — Dr. Friedrich Maurer, professor of anatomy and director of the anatomical institute in the university at Jena. — Dr. May, docent for zoölogy in the Carlsruhe Technical School. — Professor A. D. Mead, member of the Rhode Island Fish Commission. — Dr. A. Mertens, chief of the city museum at Magdeburg. — Dr. L. Milch, professor of mineralogy in the university at Breslau. — William J. Moenkhaus, assistant professor of zoölogy in the University of Indiana. — L. de Nicéville, entomologist in the Indian Museum, Calcutta. — Dr. Franz Nissl, professor extraordinary of psychiatry in the university at Heidelberg. — Dr. E. Overton, professor extraordinary of botany in the university at Würzburg. — Dr. E. Palla, professor extraordinary of botany in the university at Graz. —

B. N. Peach, district geologist of the British Geological Survey. — Dr. A. Penther, assistant in the zoölogical division of the Vienna Hofmuseum. — O. Porsch, assistant in the botanical institute at Graz. — Dr. H. Potonié, docent for paleobotany in the university at Berlin, and geologist in the Berlin Geological Anstalt. — Charles S. Prosser, professor of geology and head of the department in the Ohio State University. — Dr. Federico Raffaele, professor of zoölogy in the university at Messina. — Dr. Walter M. Rankin, professor of invertebrate morphology in Princeton University. — Clement Reid, district geologist of the British Geological Survey. — Dr. F. Reinitzer, professor of botany in the Graz Technical School. — Herbert F. Roberts, professor of botany in the Kansas Agricultural College. — Dr. Felix Rosen, professor of botany in the university at Breslau. — August Rosiwal, geologist of the Austrian Geological Survey. — Dr. M. Rudolphi, docent for physiology in the Darmstadt Technical School. — H. W. Shimer, assistant in paleontology in Columbia University. — Dr. J. Siemiradzki, professor extraordinary of geology and paleontology in the university at Lemburg. — Johann F. Snelleman, director of the Leiden Museum of Ethnology. — J. Edward Spurr, of the U. S. Geological Survey, geologist to the Sultan of Turkey. — Dr. J. Stafford, lecturer on zoölogy at McGill University. — Aubrey Strahan, district geologist of the British Geological Survey. — C. Fox Strangeways, district geologist of the British Geological Survey. — J. J. H. Teall, director of the Geological Survey of Great Britain and Ireland. — Arthur Thompson, professor of anatomy in the Royal Academy, London. — Dr. A. Voeltzkow, the zoölogist of Berlin, professor. — Dr. Weber, docent for mineralogy in the Munich Technical School. — H. B. Woodward, assistant director (for England and Wales) of the British Geological Survey. — Jay Backus Woodworth, assistant professor of geology in Harvard University. — Dr. A. Zahlbruckner, Custos of the botanical section of the Hofmuseum, Vienna.

RETIREMENTS.

Professor R. Blanchard has retired from the position of general secretary of the Zoölogical Society of France after a service of twenty-three years. — Professor Spiridion Brusina has resigned from the control of the Zoölogical Museum at Agram, which he founded thirty-three years ago. — Dr. M. Reess has retired from the professorship of botany in Erlangen.

DEATHS.

Dr. J. G. Agardh, the Swedish algologist, at Lund, Sweden, January 17, aged 88. — Andrea Balestra, conchologist, in Bassano, February 10, aged 48. — James Bennie, formerly of the Geological Survey of Scotland, January 28. — Dr. Guilio Bizzozero, the well-known pathologist of Turin, April 5, aged 55. — Dr. Frederick J. Brockway, assistant demonstrator of

anatomy in Columbia University, April 21, aged 41. — Thomas Benton Brooks, geologist and mining engineer, Nov., 20, 1900. — Paul Chaix, formerly professor of geography in the University of Geneva, aged 93. — The missionary, Armand David, the indefatigable collector of Chinese insects and birds, in Paris, November 10, aged 74. — George M. Dawson, director of the Geological Survey of Canada, March 2, aged 55. — F. K. M. Feofilaktow, formerly professor of geology in the university at Kiew, Russia. — Dr. John Gardiner, professor of biology in the University of Colorado, November 26, aged 38. — Dr. John W. Griffith, the senior editor of the well-known "Micrographic Dictionary," at Camberwell, England, aged 81. — David S. Holman, well known as a microscopist, in Philadelphia, May 13. — Baron Keiské Ito, professor of botany in the University of Tokyo, January 21, aged 99. — W. Iversen, zoölogist and librarian of the St. Petersburg Technical School, November 28. — Arthur Coppen Jones, bacteriologist, at Daavos Platz, Engadine, March 8, aged 35. — Dr. John Kloos, professor of geology and mineralogy in the Braunschweig Technical School. — Professor Christian Frederik Lütken, the celebrated Danish zoölogist, February 7. — P. O. Massalongo, entomologist, in Verona, February 23. — Dr. N. Melnikow, professor of zoölogy in the university at Kasan, January 26, aged 60. — Professor Karl Müller, anatomist of domestic animals, at Carlottenburg, near Berlin, March 6. — Dr. N. J. C. Müller, professor of botany in the Forestry School at Münden, Hannover, January 12, aged 58 years. — Dr. Robert Pohlmann, geologist and curator of the Natural History Museum at Santiago de Chili. — Dr. Thomas C. Porter, professor of botany for thirty-four years in Lafayette College, April 27, aged 79. — Audubon Whelock Ridgway, ornithologist, in Chicago, aged 24. — Dr. A. Weissbach, professor of mineralogy in the Freiburg (Saxony) school of mines, February 26, aged 67. — E. Weissieder, mineralogist, in Leopoldshall, January 28, aged 59. — William Jay Youmans, for several years editor of *Popular Science Monthly*, at Mt. Vernon, N. Y., April 10, aged 62.

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